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RESEARCH ASSOCIATIONS AND INDUSTRY

THE Board of Trade Working Party for the Linoleum and Felt Base Industry*, which included as independent members Dr. L. T. M. Gray and Prof. J. Read, leaves no room for doubt as to the importance of scientific research to that industry. The main and over-riding shortage in the industry at present is linseed oil, the supply of which has been cut to thirty per cent of the pre-war supply. This shortage is closely bound up with the world shortage of edible oils and fats, and no substantial improvement in the supplies of linseed oil for the industry is likely this year. Various substitutes for linseed oil have been tried, notably an adipic ester of trimethylolpropane in Germany, and the Working Party recommends that the industry should continue vigorous research on possible substitutes for linseed oil.

This position alone establishes the importance of scientific research to the development of the industry, even from the point of view of the supply of raw materials. While it is clear that the Government could do something more to help the industry by the provision, as the Working Party suggests, of regular information as to the short- and long-term prospects of supplies of linseed oil in view of the possible greater expense of linseed oil substitutes and the modifications to plant which may be involved, and by no longer insisting on a reduction in the allocation of linseed oil in exchange for supplies of substitute materials, the industry does not seem to be doing all that it might to help itself. A total expenditure of only £46,650 on research by nine out of the fourteen firms represents only 0·5 per cent of the turnover, and of these firms two spent an average of more than £5,000 on research during the five years 1936–39 and 1945, while three others spent between £1,000 and £3,000.

When all allowance is made for variations in size of the firms, the figures certainly suggest that several firms have not yet recognized sufficiently the need for research in an industry the future of which may well depend largely on developments in plastic materials. Linoleum itself, as the Working Party notes, is based on a form of plastic material. Further, the processes of the manufacture of linoleum are dominated by chemical changes, which are imperfectly understood. Further research might well lead to far-reaching economies in manufacturing processes, either in the use of power, as the Working Party suggests, or through the utilization of new raw materials to meet the shortage of linseed oil which, as already noted, is likely to persist for some years.

From the point of view of research, the first impression made by this report is the dynamic character of the industry to-day. It is a section of the organic chemical industry, and shares the characteristics, hazards and opportunities of that industry. Its prosperity and development may well be expected to depend on the same factors that have contributed

* Board of Trade. Working Party Reports : Linoleum and Felt Base. Pp. viii+49. (London : H.M. Stationery Office, 1947.) 1s. 6d. net.

to the development of chemical industry in general in Great Britain. Any special pleading on behalf of the linoleum industry should accordingly be excluded *a priori*, nor does the Working Party appear to advance such pleading. On the contrary, it suggests that the industry, which is too small to carry its own central research organisation, should make more use of the existing research organisations. Reference is made, in particular, to the Paint Research Station, though it is probable that the National Chemical Research Laboratory could also be of service.

Dr. J. L. Simonsen assisted Prof. Read in visiting the Paint Research Station at Teddington and reporting on the suitability of that station as a research centre for the industry. The sub-committee was very favourably impressed by the quantity and range of the work now being conducted in the Paint Research Laboratory, and considers that the Laboratory offers a valuable nucleus of buildings, equipment and staff which could be expanded with great benefit to the linoleum and felt base industry. It is suggested that, as a first step, the Paint Research Station should develop a special section to take up long-term researches with a direct bearing on linoleum and felt base. This would involve a high priority for building the expansion of the Paint Research Station's premises which is already projected, and it also implies membership of the Paint Research Association by all linoleum and felt base manufacturers, who would thus make an adequate contribution to the research association, earning in turn the usual grant from the Department of Scientific and Industrial Research.

On this proposal there are two comments to be made. The majority of the firms engaged in the manufacture of linoleum and felt base are located in the Dundee or Fife neighbourhood, and are accordingly remote from the Paint Research Station at Teddington. This disadvantage can be exaggerated, but there is this much substance in the proposals from the Scottish Reconstruction Committee, echoed at the recent Scottish Regional Conference of the Federation of British Industries, for the establishment of a Scottish Department, that the Department of Scientific and Industrial Research has in the past tended to overlook the value of the geographical proximity of a research station to the industry it serves primarily. Such proximity is of particular importance for a research association in that it helps to overcome the technical isolation in which the association must work as compared with the research department of an industrial firm.

The proposal to establish a coal utilization research station in the south of England and not on one of the coalfields is a striking example of the Department's failure to appreciate the importance of this factor. While such departmental neglect affords no warrant for such fantastic proposals as the duplication of the Department of Scientific and Industrial Research in Scotland, it does lend some support to the alternative proposal ventilated by Dr. R. Hay at the Federation of British Industries Conference and hinted at rather than advanced in the present report. If the establishment of a separate institute for long-term research relating to the linoleum and felt base industry is scarcely justified, the endowment of one or more industrial fellowships for the purpose at an institute of the type of the Mellon Institute located within easy reach of the main manufacturing area might be an equally or more effective measure than the development of a special section at the Paint Research Station at Teddington.

The admirable report which has since come from the Working Party for the Wool Industry* contains a proposal which bears on this suggestion. Discussing the special problems of the industry in Scotland, it is proposed that the production centre to be developed in connexion with the Scottish Woollen Technical College at Galashiels should be linked with a design centre and a research centre, thus providing a first-rate educational centre for all matters relating to the woollen industry. Fundamental research would continue to be confined to the existing research centres at the University of Leeds and Torridon; but it is suggested that many problems, particularly in mill organisation, machinery, materials and processes, could be dealt with at Galashiels, and that a research section there would stimulate firms to a realization of the problems lying around them, with the solution of which technical advances may be made.

Attractive as such a suggestion may appear at first sight, particularly in relation to technical education and the fostering of research at technical colleges, it will require very careful examination both in regard to its effect on the existing research association and in relation to the alternative idea of endowing fellowships at a Scottish institution of the type of the Mellon Institute. In the first place, apart from the present stringency of resources for research, both in materials and equipment as well as in man-power, there is real danger of dissipating our effort in relatively ineffective or inefficient undertakings. Elsewhere in its report, the Working Party records its conviction that the funds available for research in the industry have been quite inadequate, and that the present unsatisfactory relations that exist between the Textile Department of the University of Leeds and the Wool Industries Research Association at Torridon, and between these institutions, the technical colleges and the firms themselves, would be largely remedied by increased expenditure on research.

In the second place, it may be observed that the outlook in the industry, as disclosed in this report, does not encourage much optimism as to the local support which would be forthcoming for a new research centre at Galashiels. It is suggested that this research centre will serve to meet the needs of the smaller firms who do not employ physicists or chemists; but this argument overlooks the fundamental factor that it is the absence of technical men in these firms which is responsible for the unsatisfactory attitude to research and for the inability to apply the results of scientific advance. The attitude of many supporters of the Association at Torridon, quoted in the report, who, recognizing the high value of the discoveries made at the University of Leeds, argue that such results are of equal value to their competitors

* Board of Trade. Working Party Reports: Wool. Pp. vii+232. (London: H. M. Stationery Office, 1947.) 3s. 6d. net.

and object to the publication to the world of the results for which they subscribe for their own special use, indicates that a real change of atmosphere as well as close co-ordination is required. Furthermore, just as with the linoleum and felt base industry, many of the problems calling for research, such as dyeing problems, raw materials and machinery, and the use of substitutes, involve links with other branches of industry and can profitably be investigated by co-operative effort between industries.

That in itself is an argument for trying the idea of the industrial fellowship at an institute of the type of the Mellon Institute, and indeed indicates the character of the problems which should be referred to any such institute. Meanwhile, the Working Party has made out a convincing case for an advisory research council, even if its recommendation that the time has come for the textile industries to pool their ideas on research and set up a national textile research council for the whole of the textile industries is more debatable. The Working Party does not suggest that the joint advisory wool textile research council which it proposes should concern itself with the details of investigations; but it would be charged with the duty of arranging that the respective types of investigation cover the necessary ground, it should eliminate undue overlap, and encourage friendly co-operation. One of the principal tasks of the proposed council would be to deal with the problem of secrecy, which appears to be such a bugbear in the industry.

The Working Party suggests that the Department of Scientific and Industrial Research or other Government authority should invite representatives of universities, the technical colleges, the Wool Industries Research Association, the employers, trade unions and some independent persons to meet to establish such a council. Meanwhile, it expresses complete approval of the application of the Wool Textile Delegation to the Board of Trade for a statutory levy to raise £150,000 for general research purposes, of which £100,000 would be assigned for scientific research and the rest for market research. It suggests, however, that up to 25 per cent of the first sum should go to meet the needs of universities and technical colleges engaged in textile research, and that this amount would be administered by the proposed research council, which should also be responsible for administering on the same lines the sum of £100,000, which should be set aside from the export levy for the promotion of research.

The Working Party, in making these proposals, shows the same wide outlook as the Working Party for the Cotton Industry did in its report last year. The main proposal involves the use of the proceeds of a statutory wool levy for purposes that include development of other fibres, and it is recommended that the proposed research council should invite other industries to co-operate in such research and to contribute to its cost. Like the Cotton Working Party again, it is impressed with the need for fundamental research in the design of textile machinery, and suggests that the textile machinery-making industry should set on foot a textile machinery research association to work in close alliance with the existing research associations of the textile trades. Similarly, close liaison should be established with existing research and development institutions concerned with problems of fuel and power, to promote increased efficiency, convenience and cleanliness. It is also recommended that the present tendency towards development work as joint efforts of research centres and individual firms should be fostered. The Research Association should have at its disposal greater facilities for the experimental testing of suggestions for general experimental work on production problems, either in the form of development units or other plant in suitable premises. The present buildings at Torridon are condemned as unsuitable, and erection of a new research station as soon as possible on a much more comprehensive scale and in a central position is recommended.

These proposals show that, while critical of the Woollen Industries Research Association, the Working Party is agreed that it should be continued, and that it should receive fuller support, both financially and in other ways. For this reason the comments under the heading "Liaison and Information" are instructive. True appreciation of the spirit, meaning and implications of research is still, in the view of the Working Party, disappointingly low both among the general public and in the wool industry; and often people in responsible positions, who subscribe freely to the Research Association, have only the vaguest idea of the method and significance of what is being done. Many of the findings of research are failing to penetrate into the very places where they are needed, mainly because the language and technique of communication are inadequate.

The Working Party recognizes that only a rise in the general standard of textile education will permit a satisfactory solution, and that the trade press, which is the normal agency through which new knowledge reaches the industry, must carry a considerable share of responsibility. It also welcomes the new Department of Scientific and Technical Liaison now being set up by the International Wool Secretariat, and it is implicit in the report that the Research Association itself should give more attention to the efficiency of its liaison and information services.

Even more important, however, than the emphais of this report on the co-ordination of relations between existing research institutions is the attention directed to the true functions of a research association. Not even the report of the Cotton Working Party is calculated to stimulate more fundamental thinking about this question, and in view of Prof. Polanyi's plea at the recent British Association conference in Manchester, it is interesting to note how firmly this report insists with him that the university research departments are the chief sources and true homes of fundamental research. The main nourishment of the research associations, as of industrial research in general, must thus come from the scientific work of the universities; but the university research departments in turn will profit from adequate contact with industry, whether or not that is made through research associations.

The first function of the research association, in the view of the Wool Working Party, is to seek in its appropriate industry the broad problems and processes involved, and to submit them to careful scrutiny in the light of the best scientific knowledge available. Its second main function is to see that fundamental advances take the quickest possible path to industrial practice. To discharge these functions it is suggested that the Research Association must carry out some fundamental research of its own as well as investigate *ad hoc* problems submitted by its member firms. But the Working Party does not proceed to discuss the questions that naturally arise out of this: the nature rather than the volume of fundamental research appropriate for a research association; and the effectiveness of its *ad hoc* investigations as compared with those made by the research department of an industrial firm.

These, however, are the questions that require examination before there is any large-scale expansion of the research association movement or any decision as to its future. Further, the Wool Working Party recognizes that no amount of work by a research association can be a substitute for actual participation in research by individual firms. Meanwhile, the observations in this report on the position of textile research at the University of Leeds underlines all that was urged at the British Association Conference in Manchester regarding the endowment of university research and the importance of full freedom of investigation. Any attempt to co-ordinate all fibre studies, wherever carried out, through the establishment of a National Textile Research Council, working in close collaboration with the Textile Institute and the Society of Dyers and Colourists, as proposed in this report, cannot but lead to the study of these questions at the outset, and may in doing so render a real contribution to that overdue, factual and impartial appraisal of the position of the whole research association movement in Great Britain.

There is much in these two reports which deserves the close attention of scientific workers, from both the industrial and the academic point of view; and if the productive efficiency of Great Britain is to be raised to its appropriate level, the general and fundamental problems which they indicate in regard to the organisation of our research effort should be frankly faced, and waste of scientific effort and manpower avoided. Important as is this aspect, however, there should not be overlooked those questions of human relations which are also brought out, and the contribution which science can make in this field also. In the proposals for a joint advisory council, interrelated with like bodies for other major industries in the field of textiles, we see a tentative approach to the elaboration of a new form of industrial democracy, which by promoting fuller understanding between employers and employed in the attack on common problems, may help to solve that basic problem in the raising of the standard of efficiency and output of British industry as a whole—the creation of an atmosphere of mutual confidence, goodwill and common purpose.

ELECTROCHEMISTRY OF RADIOACTIVE SUBSTANCES

Électrochimie des substances radioactives et des solutions extrêmement diluées

Par M. Haïssinsky. (Radioactivité exposés publiés sous la direction de Prof. A. Debierne, 2.) (Actualités scientifiques et industrielles, 1009.) Pp. 68. (Paris: Masson et Cie., 1946.) 125 francs.

THIS short book by an authority on the subject is very welcome at the present time, when the supply of artificial radio-elements is on the verge of abundance. *Inter alia*, the preparation of radioactive sources must shortly become a routine operation in many fields of research, and, for this, electrochemical methods are often superior to all others in convenience, and in the purity and homogeneity of the product.

Introductory and descriptive in nature, the first three chapters deal successively, in general terms and from a practical point of view, with the chemistry of the radio-elements, with their electrochemistry (the phenomenon of spontaneous deposition, leading then to true electrolysis), and with technical details of apparatus and methods.

The fourth chapter, perhaps the most important one, discusses, on theoretical grounds, the formation of extremely thin electrolytic deposits. To account for previously observed facts, Herzfeld had modified the Nernst equation to deal with those cases where quantities insufficient to form even a monatomic layer are deposited; in so doing, however, his equation led to some conclusions which experimentally could not be verified. By the assumption of active centres, where deposition preferentially occurs, Haïssinsky argues that the Nernst equation does hold in extremely dilute solution, in the earliest stages of deposition, and shows that this is not necessarily in disagreement with Herzfeld's modification. It is unfortunate that there should still be uncertainty as to the applicability of the Nernst equation at concentrations of the order of 10^{-12} N. The earlier work of Hevesy and Paneth, Wertenstein, and Joliot, using polonium in a rather narrow concentration range (10^{-8}–10^{-11} N), gave no unambiguous Nernst shift with concentration. Later work by Haïssinsky[1], with active isotopes of bismuth, in the range 10^{-8}–10^{-12} N, indicated that such a Nernst shift does occur, and on this he bases the affirmation of p. 26. Recently declassified work by H. G. Heal[2], however, using polonium, in concentrations of 8×10^{-12} and 10^{-13} N, gives a deposition potential of still $+ 0{\cdot}64$ volt, and he denies the applicability of the equation at these concentrations.

Part of the difficulty lies, as Haïssinsky points out later (p. 47), in the use of elements of high valency (for polonium, a 100-fold concentration change produces a calculated potential change of only $0{\cdot}028$ volt —less than experimental differences in measurements on the same solution). Also, the tendency of polonium to form complexes with the great excess of anions present may obscure interpretation of results obtained with this element. It is to be hoped that the uncertainty may soon be eliminated, perhaps by the use of a radio-element of lower valency, the electrochemistry of which is already well known (for example, radio-silver).

From the theoretical discussion, the author turns to the electrochemistry of the elements of the natural radioactive series. This, as a summary of practical work, chiefly on the electrolytic deposition of the

individual elements of the series from solution and the fused state, should be of great assistance to those wishing to prepare sources for radiochemical, physical, and biological use. A discussion of artificial radio-elements and their electrochemical properties—a section necessarily short because of recent conditions—concludes this valuable book. F. MORGAN

[1] *J. chim. Phys.*, **32**, 116 (1935).
[2] National Research Council of Canada. Montreal Laboratory Report MC.33.

EMBRYOLOGY FOR MEDICAL STUDENTS

Human Embryology

By Prof. Bradley M. Patten. Pp. xv + 776. (London: J. and A. Churchill, Ltd., 1946.) 45*s*.

LITTLE more than a year ago a new English text-book of human embryology had a somewhat mixed reception in these columns[1]. Criticisms were that it did not refer to the work of certain British men of science; that a few features in some diagrams were incorrectly labelled; and that here and there the text could have been expanded to advantage. To-day another text-book with precisely the same title is addressed to medical students by Prof. Patten, a well-known and much esteemed American embryologist. It is slightly longer; slightly more lavishly, if not as well (although this is largely a matter of taste), illustrated; it covers almost the same ground; and doubtlessly it is open to some of the same criticism. It would be surprising if it were otherwise. In a subject like topographical embryology, where ideas on the genesis of organs represent dynamic concepts based on successive 'still' views of developmental processes, there is ample opportunity for differences in individual interpretation and emphasis; and furthermore, so much scope that no one person could be expected to have a first-hand knowledge of every part of the whole field.

The purpose of Prof. Patten's book is to present to the medical student a conspectus of human morphogenesis. In this, like the English volume it follows, it succeeds admirably. If either were mastered the student would know far more about general embryology than a very high proportion of lecturers and demonstrators in British anatomical departments to-day—and by the same token very much more than his clinical teachers. No doubt undergraduates are already trying to do this, for the book of a year ago is already sold out, and this is almost certain to be the fate of Prof. Patten's very readable addition to the literature of embryology.

The very fact that this is so makes one ask whether it is right to expect the average medical student to attempt as much as is covered by Prof. Patten. Prof. Patten recognizes that the medical curriculum is overcrowded, and the consequent necessity to confine his book to a 'reasonable compass'. Anatomists who have specialized in embryology may agree with him that seven hundred pages of text is a reasonable compass; and others will as cordially argue that it is far too much. The difficulty here is that, to the man who has not made organogenesis a speciality, the case for devoting to the subject a large part of the anatomical curriculum often appears much overdone—and indeed at times pressed out of the bounds of all practical possibility. Protagonists of embryology offer the excuse that the subject helps to rationalize the topographical detail of anatomy; to understand the basis of the occasional abnormality met with in clinical practice; to appreciate certain of the problems of obstetrics; and above all, that it has a major intellectual or cultural value. Item by item few would bother to dispute any of this. Yet to state that a detailed understanding of the unfolding of a topographical pattern in the embryo is a basis for comprehending the detailed pattern in the adult is to come close to the statement of a tautology. To insist that a study of embryology helps the student to understand the occasional congenital abnormality met with in clinical practice is also to state the obvious; and suggests the logical conclusion that proportionately as little time should be devoted to the subject as is taken up in clinical practice by malformations. To state that the subject has a cultural value is merely to underline what should be a quality of the entire curriculum of the medical student. One may well ask oneself whether the whole pattern of these considerations is important in the educational problem which the average medical student constitutes.

For in any event the student has to take embryology very much as a matter of faith. In Great Britain he practically never examines a section of a human or pig embryo, still less a set of serial sections—among other good reasons, for the very important one that adequate study of such material is a very time-consuming affair. Consequently the 'stills' and diagrams of his text-books represent the only direct experience the average student has of dynamic developmental processes. Such slender foundations scarcely sustain a scientific discipline. Even if they did, it is difficult to see what particular good it would be to the budding medical man. Books like Prof. Patten's are, in short, admirable guides for the student who has the opportunity and desire to study organogenesis in the laboratory itself. But they are much more than is wanted—to quote his own words—for the successful understanding of "the emergence of the various organ systems from undifferentiated primordial tissues to a point where he can recognize the beginnings of familiar adult structures"—which is about all one is likely to ask of the average medical student of to-day. What he wants is some short text that briefly explains what is known about the recognized principles of morphogenesis, and which is illustrated by really competent diagrams of the main stages in organogenesis. Since we are dealing with processes, and not fixed structures, it would be still better if one could call upon the talents of a first-class producer of 'animated films' to provide really good films of embryonic development. That would still be several steps from the original material of the subject; but it would be far closer than the student gets to-day.

For all this, there can be little doubt that Prof. Patten's main reading public will, in fact, be hurried medical students. One hopes, however, that it will receive more earnest employment as well. For topographical embryology does not need to be excused by over-emphasizing its utilitarian value in medical education. It stands in its own right, as an essential part of the story of development—and without which morphology would be only half a science. From this point of view we may count ourselves as lucky that there are always some departments of anatomy that provide the subject with a secure home. S. ZUCKERMAN

[1] *Nature*, **156**, 315 (1945).

HÆMOGLOBIN AND NITROGEN FIXATION IN THE ROOT NODULES OF LEGUMINOUS PLANTS

By Prof. D. KEILIN, F.R.S., and J. D. SMITH
Molteno Institute, University of Cambridge

IT has been shown by Kubo[1] that the root nodules of leguminous plants contain a hæmoprotein compound resembling hæmoglobin and probably acting as a store as well as a carrier of oxygen. The hæmatin nature of this pigment was confirmed by Burris and Haas[2], who believed, however, that it was not a hæmoglobin-like compound which could undergo oxygenation, but rather an oxido-reduction catalyst in which the iron changes its valency. That this pigment is a true hæmoglobin was demonstrated by Keilin and Wang[3], who purified it and found that: (1) it forms a perfectly reversible compound with molecular oxygen; (2) it has a high affinity for oxygen, the p_{50} at 15° being less than 0·1 mm. mercury; and (3) the relative affinity of this pigment for oxygen and carbon monoxide in terms of the equilibrium constant $K = [HbCO]\,[pO_2]/[HbO_2]\,[pCO]$ is about 37 at 15° C. They also determined the spectrophotometric absorption curves of this hæmoglobin and of its compounds with oxygen and carbon monoxide.

The constant presence of this pigment in effective nodules of all leguminous plants, and the fact that nitrogen fixation in these nodules is inhibited by very low partial pressure of carbon monoxide, suggested that the hæmoglobin is in some way connected with the process of nitrogen fixation.

The presence of hæmoglobin in nodules was confirmed by Virtanen[4] and by Virtanen and Laine[5]. They, however, claimed that in addition to hæmoglobin the root nodules always contain methæmoglobin, the concentration of which increases when the plants are placed in the dark. They assumed that in nitrogen fixation the function of hæmoglobin is connected not so much with its property of oxygenation to oxyhæmoglobin as with its oxidation to methæmoglobin.

It must be remembered that whereas hæmoglobin (Hb) and oxyhæmoglobin (HbO_2) are compounds of divalent iron, methæmoglobin (Methb), which is a true oxidation product of hæmoglobin, contains trivalent iron.

In the present communication we propose to give a brief account of our study of the state of hæmoglobin within the nodules of plants kept under different conditions, and to examine the suggestions put forward by Virtanen and Laine[5] as to the mode of action of hæmoglobin in the nitrogen fixation by nodules.

State of Hæmoglobin in Nodules of Plants in the Light and in the Dark

The plant used in our investigations was the soya bean. The nodules were produced by three strains of *Rhizobium*: 505 and 507 supplied by Dr. H. G. Thornton of Rothamsted Experimental Station, and the strain 2196 obtained from the National Collection of Type Cultures. Two of these, 505 and 2196, were 'effective' strains, whereas the strain 507 was 'ineffective'. The experiments were carried out between June and September 1946 with plants grown either in nutrient solutions or in soil, and the seeds were germinated either in sterilized sand or in unsterilized soil. The state of the hæmoglobin was determined by direct spectroscopic examination of nodules immediately after their removal from the roots. For this purpose each nodule is washed, and cut with a razor blade into three slices. The central slice with parallel surfaces is placed on a slide in a drop of water and examined with the microspectroscope, using a strong source of light. Other nodules were examined crushed between two slides. Oxyhæmoglobin was recognized by the absorption bands at about 574 and 540 mμ, hæmoglobin by a single band at 557 mμ, whereas methæmoglobin, if present, should show a band at about 630 mμ. In certain cases sodium fluoride was added to the crushed or sliced nodule, which was then examined for the band of fluoride methæmoglobin lying at about 610 mμ.

Plants grown in nutrient solutions. On the opening of the second pair of leaves the seedlings, grown in sterilized sand, were transferred to 1·5 l. conical flasks containing a nutrient solution. The plants were inoculated by the addition to the nutrient solution of a suspension of a pure culture of *Rhizobium*. Three sets of plants nine weeks old bearing nodules produced by strains 505, 507 and 2196 of *Rhizobium* were each divided into two groups, one of which was left with the tops exposed to light, whereas the plants of the other groups were protected from light by wire cages covered with black cloth.

After eight days, several specimens of plants belonging to each of the six groups were removed and their nodules were examined spectroscopically. The main results of this examination can be summarized as follows: (1) nodules produced by the ineffective strain 507 were devoid of hæmoglobin both in specimens kept in the light and those in the dark; (2) nodules produced by effective strains (505 and 2196) contained only hæmoglobin and oxyhæmoglobin; no methæmoglobin was visible even in nodules of plants kept in the dark for about eight days; (3) on the addition of sodium fluoride to crushed nodules the band of fluoride-methæmoglobin, which slowly appeared, was very feeble and of the same intensity in nodules from plants kept in light and those in the dark.

Plants grown in soil. The seedlings were inoculated with a suspension of strain 505 of *Rhizobium*, and seventeen days later they were separated into two groups: the plants of one group were left in light, whereas those of the other group were transferred to closed containers in a darkened part of the greenhouse. Samples of both groups of plants were taken out and their nodules examined spectroscopically. After two and four days in the dark, only hæmoglobin and oxyhæmoglobin were present in the nodules, and no trace of methæmoglobin could be detected. After twelve days in the dark the leaves of the plants were yellow and falling. The contents of the nodules were brown and devoid both of hæmoglobin and methæmoglobin. The total hæmatin content of such nodules estimated as pyridine hæmochromogen was much lower than that of the nodules from normal plants.

This experiment was repeated using older plants which had begun seed production and were bearing larger nodules. Here again, in plants kept in the dark and examined daily, no methæmoglobin could be detected by direct spectroscopic examination of crushed or sliced nodules, and only after seven days

in the dark was a small amount of fluoride-methæmoglobin formed on addition of sodium fluoride to crushed nodules.

Localization and Concentration of Hæmoglobin Within Nodules

We found it possible to demonstrate that within the nodule hæmoglobin is confined to the large cells containing *Rhizobium*. This was done either by direct microspectroscopic examination of thick slices of nodules, or by observing the distribution of the blue colour produced by the peroxidase action of hæmoglobin in microtome sections of nodules about 10 mμ in thickness treated with benzidine and hydrogen peroxide.

The concentration of hæmoglobin in the bacteria-containing cells of dwarf bean (*Phaseolus vulgaris*) nodules, estimated in crude extracts of nodules as pyridine hæmochromogen, was found to be about $1{\cdot}1 \times 10^{-4}$ gm. mol. hæmatin/l. The mean value obtained directly in slices of nodules and including hæmatin of cytochrome was $2{\cdot}3 \times 10^{-4}$ gm. mol. hæmatin/l. These estimations were carried out with the microspectroscope and the double-wedge trough, as previously described[6,7].

Hæmoglobin and Nitrogen Fixation in Nodules

Before the red pigment in nodules was recognized as hæmoglobin, Virtanen and his co-workers suggested that the first product of nitrogen fixation in nodules is hydroxylamine (NH_2OH), and that this combines with oxalacetic acid produced in the green portion of the plant to form the oxime, which on reduction gives rise to *l*-aspartic acid.

When the presence of hæmoglobin in nodules was definitely demonstrated[1,2], Virtanen and Laine[5] made an attempt to correlate its function with their hydroxylamine–aspartic acid mechanism of nitrogen fixation. For this purpose they found it necessary to postulate the valency changes of hæmoglobin iron and the reversibility of the reaction of decomposition of hydroxylamine by hæmoglobin.

According to Virtanen and Laine[5] the part played by hæmoglobin in nitrogen fixation can be represented schematically as follows:

$$N_2 + \text{Methb } (Fe^{III}) \rightleftharpoons NH_2OH + \text{Hb } (Fe^{II})$$

$$\text{reduction} \downarrow \quad + \text{oxalacetic acid}$$

$$\textit{l}\text{-aspartic acid} \leftarrow \text{oxime}$$

That the mechanism of nitrogen fixation involves a cyclic change of the valency of hæmoglobin iron is, according to them, supported by the following considerations: "The changes in the colour of nodules . . . depend on the intensity of light, and follow to a surprising extent the variations of oxalacetic content of the plant juice. On bright days the oxalacetic acid content of the plant juice is at its highest; during cloudy periods it falls sharply and after forty-eight hours in total darkness disappears completely." Accordingly, they claim to have found that "during cloudy days the brown colour deepens in the nodules as the balance is shifted to methæmoglobin".

The hydroxylamine–aspartic acid theory has already been carefully examined by Wilson[8] in his masterly review of the whole subject of nitrogen fixation in plants. We therefore propose to deal only with the views put forward by Virtanen and Laine[5] as to the mode of action of hæmoglobin in nitrogen fixation by root nodules. Even if their hydroxylamine–aspartic acid mechanism is accepted, several considerations, which we shall briefly examine, militate against their views of the part played by hæmoglobin in this mechanism.

(1) Our experiments failed to confirm their observations as to the presence of methæmoglobin in root nodules of plants even when the latter were kept in darkness for several days. On spectroscopic examination nodules show only the absorption bands of oxyhæmoglobin, which are gradually replaced by the single band of hæmoglobin. This deoxygenation, which is due to the normal respiratory activity of nodules including *Rhizobium*, is more rapid when nodules are examined compressed or crushed between two slides. The appearance of methæmoglobin in Virtanen and Laine's experiments was probably due to the fact that they worked with nodule extracts in which hæmoglobin undergoes oxidation by quinones formed during the extraction. In fact, the formation of methæmoglobin is more rapid in extracts from nodules of peas and beans, which are particularly rich in the polyphenol oxidase system, than in those of soya bean.

(2) The brown colour of nodules observed by Virtanen and Laine was not necessarily due to the formation of methæmoglobin, since the brown coloration of degenerating nodules, like that of other damaged plant tissues, may be due to the products of oxidation of phenolic substances by a polyphenol oxidase.

(3) Their statement that "methæmoglobin is reduced to hæmoglobin by the action of oxalacetic acid" is misleading, since oxalacetic acid reduces neither methæmoglobin nor any other hæmatin compound.

(4) The mechanism of decomposition of hydroxylamine by hæmoglobin is more complicated than was shown in the equation given by these workers and which was based on Letsche's observations[9]. In fact, the investigations by Lipschitz and Weber[10] and Roche[11] demonstrated that not only nitrogen, but also oxygen, ammonia and possibly nitrate are formed in the course of the catalytic oxidation of hydroxylamine by oxyhæmoglobin, the oxygen liberated from the latter being partly used in the oxidation reactions. Were Virtanen and Laine right in representing the formation of hydroxylamine as a part of a reversible equilibrium reaction of its decomposition by hæmoglobin, the production of hydroxylamine would require not only molecular nitrogen but also ammonia and possibly nitrate.

Conclusions

Our experiments clearly show that within the root nodules of leguminous plants hæmoglobin displays its usual property of oxygenation ($Hb + O_2 \rightleftharpoons HbO_2$). On direct spectroscopic examination, the nodules show only the mixture of hæmoglobin and oxyhæmoglobin. No methæmoglobin could be detected in nodules even if the plants were kept in the dark for several days. Neither experimental evidence nor general considerations support the view that the nitrogen fixation in root nodules involves a cyclical change of the valency of hæmoglobin iron. Moreover, it seems unlikely that oxido-reduction reactions

in nodules are catalysed by a compound such as hæmoglobin, which has the remarkable property of oxygenation and is therefore an excellent oxygen carrier but a very inefficient catalyst. Although one cannot dismiss the possibility that under certain conditions hæmoglobin may act as an oxido-reduction catalyst, no evidence is so far available that this applies to hæmoglobin of root nodules.

On the other hand, the fact that this hæmoglobin is present in root nodules of every leguminous plant, that the pigment is formed only in nodules produced by an 'efficient' strain of *Rhizobium*, that the pigment is localized only within the large cells containing symbiotic organisms and that nitrogen fixation by nodules is strongly inhibited by small concentration of carbon monoxide, leave very little doubt that the activity of hæmoglobin is linked with the process of symbiotic nitrogen fixation. The presence of hæmoglobin in root nodules, therefore, will have to be taken into consideration in all further studies of nitrogen fixation by leguminous plants.

We are very grateful to Dr. H. G. Thornton for the strains 505 and 507 of *Rhizobium* used in this investigation.

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PROCESSES INVOLVING CHARGED MESONS

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IN recent investigations with the photographic method[1,2], it has been shown that slow charged particles of small mass, present as a component of the cosmic radiation at high altitudes, can enter nuclei and produce disintegrations with the emission of heavy particles. It is convenient to apply the term 'meson' to any particle with a mass intermediate between that of a proton and an electron. In continuing our experiments we have found evidence of mesons which, at the end of their range, produce secondary mesons. We have also observed transmutations in which slow mesons are ejected from disintegrating nuclei. Several features of these processes remain to be elucidated, but we present the following account of the experiments because the results appear to bear closely on the important problem of developing a satisfactory meson theory of nuclear forces.

In identifying the tracks of mesons we employ the method of grain-counting. The method allows us, in principle[3], to determine the mass of a particle which comes to the end of its range in the emulsion, provided that we are correct in assuming that its charge is of magnitude $|e|$. We define the 'grain-density' in a track as the number of grains per unit length of the trajectory. Knowing the range-energy curve for the emulsion[4], we can make observations on the tracks of fast protons to determine a calibration curve showing the relation between the grain-density in a track and the rate of loss of energy of the particle producing it. With this curve, the observed distribution of grains along the track of a meson allows us to deduce the total loss of energy of the particle in the emulsion. The energy taken in conjunction with the observed range of the particle then gives a measure of its mass.

We have found that the above method gives satisfactory results when, in test experiments, it is applied to the determination of the mass of protons by observations on plates developed immediately after exposure. The errors in the observed values, based on grain-counts along individual tracks, are only a little greater than those corresponding to the statistical fluctuations associated with the finite number of grains in a track. As we have previously emphasized, however, serious errors arise when the method is applied to the plates exposed for several weeks to the cosmic rays[5]. These errors are due mainly to the fading of the latent image in the time elapsing between the passage of the particle and the development of the plate.

We have attempted to allow for fading by determining a calibration curve for each individual plate by grain-counts on the tracks of a number of protons, chosen at random from those originating in 'stars'. Such a calibration curve corresponds to an average value of the fading of the tracks in the plate. While we thus obtain improved mean values for the mass of particles of the same type, as shown by test measurements on the tracks of protons other than those used in making the calibration, the individual values are subject to wide variations. In no case, however, have mass determinations by grain-counts of particles, judged to be protons from the frequency of the small-angle scattering, given values exceeding 2,400 m_e or less than 1,300 m_e.

In these circumstances it is not possible to place serious reliance on the masses of individual mesons determined by grain-counts; and we employ the method, in the present experiments, only to distinguish the track of a meson from that of a proton. In searching a plate, an experienced observer quickly learns to recognize the track of a meson by inspection, provided that its range in the emulsion exceeds 100μ. Nevertheless, we regard it as established that a particular track was produced by a meson only if both the grain-density and the frequency of the Coulomb scattering correspond to the values characteristic of a particle of small mass. We have considered the possibility that as a result of a rare combination of circumstances we might, in spite of the above precautions, wrongly attribute the track of a proton to a meson of mass less than 400 m_e. It is difficult to give a numerical estimate of the probability of making such an error, but we believe it to be very small.

Secondary Mesons

We have now made an analysis of the tracks of sixty-five mesons which come to the end of their range in the emulsion. Of these, forty show no evidence for the production of a secondary particle. The remaining twenty-five lead to the production of secondary particles. Fifteen of them produce disintegrations with the emission of two or more heavy particles, and from each of the remaining ten we

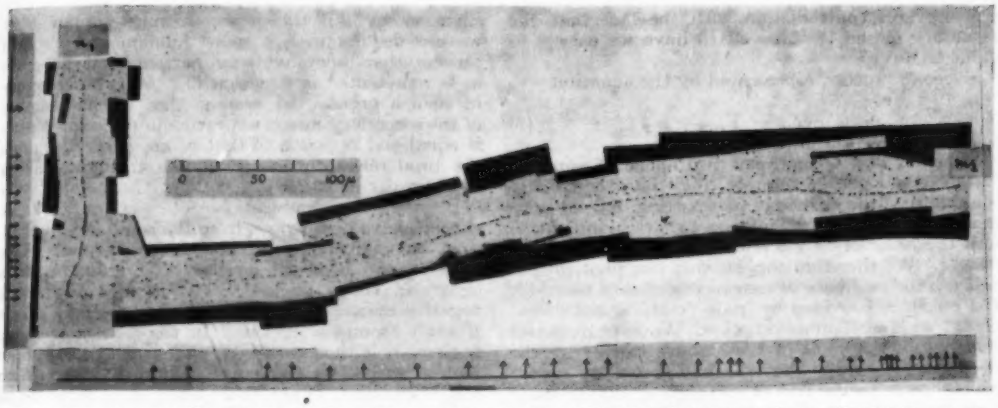

Fig. 1. Observation by Mrs. I. Roberts. Photomicrograph with Cooke × 45 'fluorite' objective. Ilford 'Nuclear Research', boron-loaded *C2* emulsion. m_1 is the primary and m_2 the secondary meson. The arrows, in this and the following photographs, indicate points where changes in direction greater than 2° occur, as observed under the microscope. All the photographs are completely unretouched

observe a single secondary particle. Of these latter events, the secondary particle is in four cases a hydrogen or heavier nucleus; in four other cases the identification is uncertain, and in the last two cases it is a second meson.

Fig. 1 is a reproduction of a mosaic of photomicrographs which shows that a particle, m_1, has come to the end of its range in the emulsion. The frequent points of scattering and the rapid change of grain-density towards the end of the range show that the track was produced by a meson. It will be seen from the figure that the track of a second particle, m_2, starts from the point where the first one ends, and that the second track also has all the characteristics of that of a particle of small mass. A similar event is shown in Fig. 2. In each case the chance that the observation corresponds to a chance juxtaposition of two tracks from unrelated events is less than 1 in 10^9.

Grain-counts indicate that the masses of the primary particles in Figs. 1 and 2 are 350 ± 80 and $330 \pm 50\ m_e$, respectively; and of the secondary particle in Fig. 1, $330 \pm 50\ m_e$, the limits of error corresponding only to the standard deviations associated with the finite numbers of grains in the different tracks. All these values are deduced from calibration curves corresponding to an average value of the fading in the plate, and they will be too high if the track was produced late in the exposure, and too low if early. We may assume, however, that the two-component tracks in each event were produced in quick succession and were therefore subject to the same degree of fading. In these circumstances the measurements indicate that if there is a difference in mass between a primary and a secondary meson, it is unlikely that it is of magnitude greater than $100\ m_e$. The evidence provided by Fig. 2 is not so complete because the secondary particle passes out of the emulsion, but the variation in the grain density in the track indicates that it was then near the end of its range. We conclude that the secondary mesons were ejected with nearly equal energy.

We have attempted to interpret these two events in terms of an interaction of the primary meson with a nucleus in the emulsion which leads to the ejection of a second meson of the same mass as the first. Any reaction of the type represented by the equations

$$A_Z^N + \mu_{-1}^0 \rightarrow B_{Z-1}^N + \mu_{+1}^0 \text{ or } A_Z^N + \mu_{+1}^0 \rightarrow C_{Z+1}^N + \mu_{-1}^0, \quad (1)$$

in which A represents any stable nucleus known to be present in the emulsion, involves an absorption

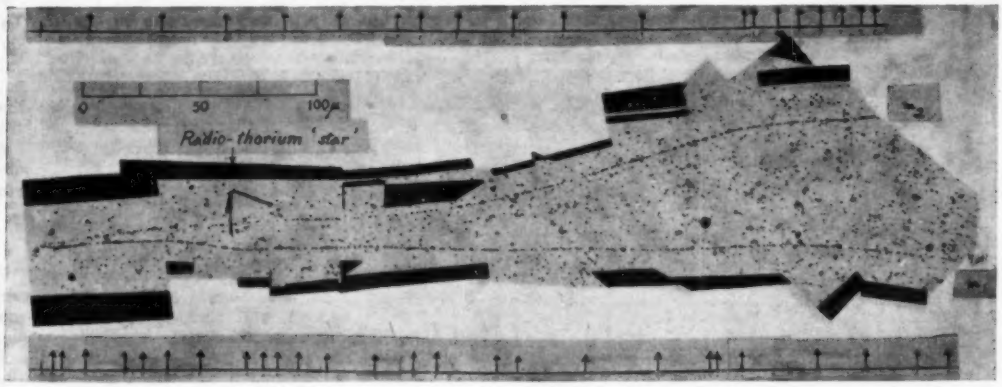

Fig. 2. Observation by Miss M. Kurz. Cooke × 45 'fluorite' objective. Ilford 'Nuclear Research' emulsion, type *C2*, boron-loaded. The secondary meson, m_2, leaves the emulsion

of energy, in contradiction with the fact that the secondary meson is observed to have an energy of about 2 MeV.

A second process, represented by the equation

$$Ag_{,} + \mu^{\circ}_{-1} \rightarrow X_{z} + Y_{z-z} + \mu^{\circ}_{+1}, \qquad (2)$$

in which X and Y represent two nuclei of approximately equal charge number, may be energetically possible, but the chance of it occurring in conditions where the total energy of the two recoiling nuclei is of the order of only a few million electron-volts is remote. We therefore suggest that our photographs indicate the existence of mesons of different mass[5,6,7]. The evidence provided by grain counts is not inconsistent with such an assumption. We have no direct evidence of the signs of the charges carried by the two mesons, except that the one secondary meson which comes to the end of its range in the emulsion does not lead to a disintegration with the emission of heavy particles. If, however, we assume that the transmutation corresponds to the interaction of the primary meson with a light nucleus, of a type represented by the equation

$$C^{12}_{6} + \mu^{\circ}_{-1} \rightarrow Be^{12}_{4} + \mu^{\circ}_{+1}, \qquad (3)$$

the difference in mass of the two mesons must be of the order of 60 m_e, according to estimates of the mass of the beryllium nucleus.

The only meson theory, to our knowledge, which assumes the existence of mesons of different mass is that of Schwinger[8]. It is visualized[9] that a negative vector meson should have a very short life and should lead to the production of a pseudo-scalar meson of the same charge but lower mass, together with a quantum of radiation. It will therefore be of great interest to determine whether the secondary meson, in transmutations of the type we have observed, is always emitted with the same energy. If this is so, we must assume that we are dealing with a more fundamental type of process than one involving particular nuclei such as is represented in equation (3). If, as an example of such a process, we assume that the momentum of the secondary meson appearing in our experiments is equal and opposite to that of an emitted photon, the total release of energy in the transmutation is of the order of 25 MeV.

In recent communications[10,11] very radical conclusions have been drawn from the results of observations on the delayed coincidences produced by positive and negative mesons in interactions with light and heavy nuclei[12,13]. It is assumed that a negative meson, at the end of its range, falls into a K orbit around a nucleus. In the case of a heavy nucleus, it is then captured, giving rise to a disintegration with the emission of heavy particles. With a light nucleus, on the other hand, it is regarded as suffering β-decay before being captured, so that, like a positive meson, it can produce a delayed coincidence. The conclusion is drawn that the nuclear forces are smaller by several orders of magnitude than has been assumed hitherto. Since our observations indicate a new mode of decay of mesons, it is possible that they may contribute to the solution of these difficulties.

Emission of Mesons from Nuclei

Fig. 3 shows a mosaic of photomicrographs of a disintegration in which six tracks can be distinguished radiating from a common centre. The letters at the edge of the mosaic indicate whether a particular track passes out of the surface of the emulsion, a, into the glass, g, or ends in the emulsion, e. The grain-density in tracks a and c indicate that the time between the occurrence of the disintegration and the development of the plate was sufficiently short to avoid serious fading of the latent image.

The track marked f suffers frequent changes in direction due to scattering, and there is a very rapid change in the grain-density in moving along the trajectory. These two features, taken together, make it certain that the track was produced by a light particle, and grain counts give an estimate for the mass of 375 ± 70 m_e[14].

We have now observed a total of 1,600 disintegration 'stars', in each of which three or more charged particles are ejected from a nucleus. Of these, 170 correspond to the liberation of an amount of energy equal to, or greater than, that in the 'star' represented in Fig. 4, but only in two cases can we identify an

Fig. 3. Observation by Mrs. I. Roberts. Photomicrograph with Cooke × 45 'fluorite' objective. Ilford 'Nuclear Research' boron-loaded C2 emulsion. The track (*b*) dips steeply and its apparent grain density is greater than the true value through foreshortening. Both (*b*) and (*c*) were probably produced by α-particles

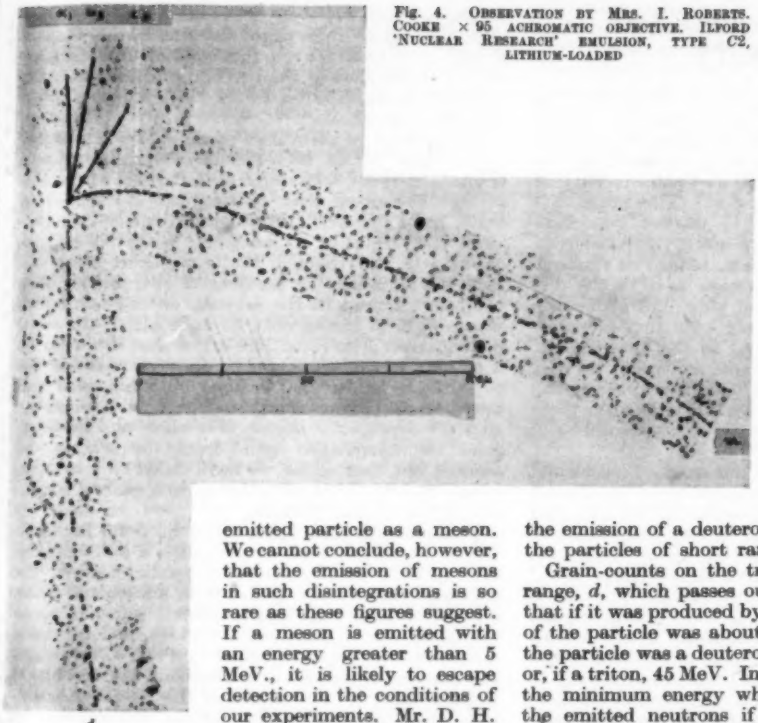

Fig. 4. Observation by Mrs. I. Roberts. Cooke × 95 achromatic objective. Ilford 'Nuclear Research' emulsion, type C2, lithium-loaded

emitted particle as a meson. We cannot conclude, however, that the emission of mesons in such disintegrations is so rare as these figures suggest. If a meson is emitted with an energy greater than 5 MeV., it is likely to escape detection in the conditions of our experiments. Mr. D. H. Perkins, of the Imperial College of Science and Technology, has shown that, in the B_1 emulsion, the grain-density in the track of a meson becomes very small at energies greater than 2 MeV., and we must anticipate a similar result in the C_2 emulsion at higher energies. Our observations are therefore not inconsistent with the view that the ejection of mesons is a common feature of the disintegration of nuclei by primary particles of great energy, and that the present instance, in which the velocity of ejection has been exceptionally low so that an identification of the particle has been possible, is a rare example. It is possible that the example of meson production recently described[15] is due to a similar process, produced by a primary particle of higher energy, in which some of the heavier fragments emitted on the disintegration have escaped detection because of the depth inside the lead plate at which the event occurred.

The disintegration shown in Fig. 3 may be the representative of a type, common in the high atmosphere with particles of great energy. In the present instance the energy of the primary particle must have been of at least 200 MeV., and, if its mass was equal to or less than that of a proton, it would not have been recorded by the emulsion.

Disintegrations Produced by Mesons

The observation of the transmutations of nuclei by charged mesons has led to the suggestion of a method for determining the mass of these particles based on observations of the total energy released in the disintegration[1,2]. In attempting to apply the method, we meet the difficulty of identifying the particular type of nucleus undergoing disintegration and of taking account of any ejected neutrons which will not be recorded by the emulsion. A photograph of such a disintegration which, at first sight, appears to allow us to draw definite conclusions, is shown in Fig. 4. In the photograph, the tracks of four heavy particles can be distinguished, of which the short tracks α_1, α_2 and α_3 end in the emulsion; α_1 and α_2 were certainly produced by α-particles, and grain-counts show that α_3 is due to a proton. The observations are therefore consistent with the equation

$$N_7^{14} + \mu_{-1}^0 \rightarrow 2He_2^4 + H_1^1 + H_1^1 + 4n_0^1; \quad (4)$$

or, less probably, to a similar equation involving the emission of a deuteron or a triton in addition to the particles of short range.

Grain-counts on the track of the particle of long range, d, which passes out of the emulsion, indicate that if it was produced by a proton, the initial energy of the particle was about 15 MeV. Alternatively, if the particle was a deuteron, its energy was 30 MeV.; or, if a triton, 45 MeV. In any case, we can determine the minimum energy which must be attributed to the emitted neutrons if momentum is to be conserved in the disintegration. As a result, we find a minimum value for the mass of the primary meson of 240 m_e. The value determined by grain-counts is also 240 ± 50 m_e.

In view of the recent results of experiments on delayed coincidences, referred to previously[12,13], such results must, for the present, be accepted with great reserve. We must expect the liberation of an amount of energy of magnitude 100 MeV. in any nucleus to lead to the ejection of several particles, some of which may be neutrons. There is therefore no firm basis for assuming that the disintegration represented in Fig. 4 corresponds to the disintegration of a nucleus of nitrogen rather than one of silver or bromine. Indeed, the delayed coincidence experiments suggest that the second assumption is the more probable. When a sufficient number of observations with loaded plates has been accumulated, it may be possible to draw more definite conclusions from observed regularities in the modes of disintegration of particular types of nuclei.

A detailed account of the experiments will be published elsewhere.

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UNIVERSITIES AND THE COMMUNITY

THAT public discussion on such a subject as "The Place of Universities in the Community" would range over a wide field was to be expected, and the one-day conference on that subject arranged by the British Association on May 10 at the University of Manchester proved no exception. The immediate purpose of the conference, to discuss important problems arising out of the projected expansion of the universities of Great Britain, tended at times to be overlooked by those who took part in the discussions at both sessions, and while the conference made some contribution to the education of public opinion as to what is involved in the expansion of the universities, particularly on the scientific side, little was added to what has already emerged in the debate between men of science and others on these questions, both before and after the appearance of the Barlow Report.

The first of the two sessions was devoted specifically to the consideration of the implications of the Barlow Report. Lord Simon of Wythenshawe, who presided over this session, did his best to keep the discussion on realistic lines but contented himself in his opening remarks with presenting the administrative background to the Barlow Report, pointing out that it was only one of a number of such official reports dealing with the question of capacity of the universities to provide the trained men and women which the community requires. He referred specifically to the earlier Goodenough, Teviot, McNair and Clapham Reports, and to the more recent Scarborough Report; but in view of what was said later by Prof. M. Polanyi, he might well also have cited the earlier Barlow Report on scientific staff. Lord Simon then quoted from the "Note on University Policy and Finance in the Decennium 1947–56" (which was discussed in *Nature* of April 12, p. 483), and emphasized the acceptance by the universities of the view that the Government has the right and the duty to satisfy itself that every field of study which in the national interest ought to be cultivated in Great Britain is in fact being adequately cultivated in the universities, and that the universities are using their resources with full regard both to efficiency and to economy. If the universities are collectively to devise and execute policies calculated to serve the national interest, the University Grants Committee would require strengthening, and Lord Simon referred to the recent appointment of a whole-time deputy chairman and to the Chancellor of the Exchequer's indication of the ultimate expansion of the grant to the universities to be administered by the Committee to at least £16–£20 millions as against £2–£4 millions before the War.

These figures were probably less effective in indicating what is immediately involved than Lord Simon's incidental remark that doubling the output of scientific workers within five years is a rate of expansion much greater than has ever been contemplated in the United States. The administrative and financial aspects were, however, scarcely again considered in the discussion. Prof. P. M. S. Blackett, who followed, thought that sufficient talent is available to provide the increased number of scientific workers required, and referred in particular to the reserve demand for such trained individuals represented by the teaching profession and by private industry, which probably needs more men of science than it recognizes. He urged that the Barlow Report should be followed by a further statistical inquiry into both the sources from which students enter the universities and the future of the graduates when they leave them.

One at least of these lines of thought was pursued by Dr. Eric James, high master of the Manchester Grammar School, who urged that the great weakness of the Barlow Report is that no evidence was taken from the schools as to their capacity to provide the requisite number of potential science graduates. He thought that the report made insufficient allowance for the number of trained science teachers required in the schools, on the quality of whose work in the schools, he maintained, the work of the universities rests. He urged that it should be a priority of the first order to discover where in the educational ladder the wastage of intelligence and talent occurs; emphasizing that we should remember that the educational system is a whole and not consider the universities apart from the schools, he pointed out that so far we have failed to formulate in any specific terms our ideas as to a general education for scientific workers.

This plea was later taken up by Sir John Lennard-Jones. He urged that, as providing a link between the nation's intelligence and public affairs, the university has a duty to the State and should make a point of being fully and accurately informed as to the nation's need for trained workers, and moved a resolution which was seconded by Prof. J. D. Bernal and adopted at the end of the session. The resolution recommended to the Council of the British Association that the University Grants Committee be invited, in collaboration with the universities, (1) to make extensive factual surveys of the openings for graduates in the national life; (2) to maintain records of the careers of university graduates and the measure of their success in their professions; and (3) to publish periodic reports of the results of such surveys for the guidance of universities and schools. Whatever reservation individuals may have felt about the wisdom of asking the University Grants Committee to undertake this task—and misgivings were expressed in private if not publicly—the importance of university co-operation in appointments work was fully recognized, although no one pointed out that the Hankey Committee has already recommended that this work should be undertaken by the Higher Appointments Department of the Ministry of Labour.

Other points raised in the morning discussion were the age at which choice of a scientific career is usually determined, the detrimental effect of existing overcrowding and of the shortage of teaching staff. The importance of careful selection of students in university expansion and of encouraging adaptability and discouraging the intensive specialization which hinder mobility were noted. Mr. Ritchie Calder, commenting on the danger of middle-class unemployment, urged that greater emphasis should be placed on the regional character of the university; a position in which only 10 per cent of science graduates from Scottish universities find employment in Scotland is most unsatisfactory.

Opening the second session of the conference, which was to consider more specifically research and organisation, Sir Henry Dale, who presided, suggested that with the universities dependent on the Government for more than seventy-five per cent of

their income, the influence of Government departments might become a serious factor in the expenditure of funds on research. Sir Henry Dale voiced once more the fears that he has often expressed that the war-time practice of the universities of carrying out research on subjects laid down by outside authorities might be perpetuated. He emphasized the vital importance of the universities maintaining, in Britain and elsewhere, their full independence, and reiterated that the proper function of the universities is to promote free research with no immediate objectives but to widen the boundaries of knowledge, in contradistinction to prescribed research undertaken for the particular end of solving an immediate practical problem.

No evidence was given during the meeting that either industry or the Government is offering research endowments to the universities to which restrictive or secrecy conditions are attached, and it is noteworthy that all recent reports on research and the universities which have recognized the increasing dependence of the universities on Government financial support have been confident of the ability of the universities to maintain their independence. Nevertheless, the afternoon session adopted the resolution moved by Sir Henry Dale recommending the Council of the British Association to make representations to the competent authorities of all universities in the British Empire, urging that under the normal conditions of peace no contract for research should be accepted by the scientific departments of any of these universities if its terms included any restriction on freedom of publication.

In their plea for a follow-up of the Barlow Report by an investigation of the educational ladder at the school stage, Prof. Blackett and Dr. James introduced the first new distinctive note; Prof. M. Polanyi struck the second. In a paper on the organisation of universities, without pursuing the secrecy theme, Prof. Polanyi spoke strongly for the universities as the natural nurseries and homes of fundamental research. He recognizes the twin relations of teaching and research, and he pleaded that the advancement of learning depends on the universities being maintained as the well-springs of discovery. As Sir Henry Dale had said, it is the function of the university to hold aloft the search for truth in all its aspects; but when Prof. Polanyi added that it is waste of time to endow academic research workers unless the recipients are left free to use the funds at their own discretion, he gave expression to a principle which might well be re-considered by those industrial firms who have, as he indicated, tended to enter the academic field. Doubtless the distinction may not always be easy to maintain, but Prof. Polanyi equally insisted that the university itself should be careful not to be tempted into the investigation of practical problems which lie outside its own experience.

This most significant passage in Prof. Polanyi's paper was rather overlooked in the discussion, which seized, first on his reference to the importance of refusing to fill vacancies in senior appointments with men or women below a certain level of distinction and of not regarding too closely the special field of inquiry, even if this involves some over-crowded departments and others with chairs vacant indefinitely; and secondly, on his defence of some disparity between academic salaries and those of other professional positions in industry or elsewhere. Prof. Polanyi also maintained that unless society appreciates science for its own sake, it will not continue for long to cultivate genuine scientific research, and accordingly in the long run the universities depend for their existence on the recognition of cultural obligations by the nation. He also insisted that since it is impossible to recognize and subsidize all the growing points of science, the universities, which uphold the broad principle that their task is to supply individual creative minds with the opportunities to do the work of their own choice, cannot agree with the Vice-Chancellor's Committee that it is their function to plan to meet the whole range of national need for higher teaching and research.

Prof. Bernal did not altogether follow Prof. Polanyi in this view. His discussion of research was obviously coloured by his recent experience of war-time conditions, and he distinguished research as of two types: subjective research, which he agreed should be left to the universities, and the objective and prescribed research, distinguished by Sir Henry Dale. While subjective research is the proper function of the universities, Prof. Bernal insisted that the greater need is for a new type of research worker and director able to integrate this with other activities. He urged that social and economic problems can likewise be tackled on scientific lines; here he was obviously less concerned with the creative aspect and the freedom of choice stressed by Prof. Polanyi than with the question of organisation and the fact that the individual scientific worker might exercise his choice without adequate knowledge. He supported both the regional work of the university—regional contacts, he believes, will help to suggest continually fruitful problems for investigation by the universities, which should make it their business to discover the needs and problems of the region—and the cultural value of scientific research. We need a unitary culture which to-day must contain a scientific method, just as the experimental method would play a part in uniting knowledge. If an adequate social philosophy is not yet fully formed, we have at least learned that the whole approach to social problems as well as to physical problems should be scientific.

In a somewhat rambling discussion, little was said which had not already been ventilated in previous reports on the universities and research. Some points in that from the Association of Scientific Workers in particular were mentioned. The claims of social science as presented in the Clapham Report, and also of adult education, on the support of the universities were also emphasized. Dr. C. H. Desch referred to the changing outlook in the steel industry and to the demand for scientific workers for research and management positions in contrast to a demand merely for testing work, and to the way in which patents policy offsets the obsolete tendency to secrecy in industrial research. Commenting on the need for providing for the new growing points in science, Prof. Polanyi's suggestion that chairs should be left vacant found some support, Dr. Gordon observing that the universities should make it clear to the Government beforehand that they do not propose to retain inferior men in professorial chairs even if appointed on trial. His comment about differentiation in salary scales, however, was challenged; Prof. Polanyi had not denied that university salaries are in need of revision upwards; the scientific worker in a university should be remunerated on a scale which permits him to maintain a family.

OBITUARIES

Prof. V. M. Goldschmidt, For.Mem.R.S.

VICTOR MORITZ GOLDSCHMIDT, the eminent geochemist, formerly professor of mineralogy and geology in the University of Oslo, died on March 20.

He was born in Zurich in 1888, the son of H. J. Goldschmidt, who became professor of chemistry at Oslo in 1900. He entered the University of Oslo in 1905, taking as his main subjects chemistry, mineralogy and geology, and there came under the inspiring influence of Prof. W. C. Brögger, whom he was eventually to succeed. He was appointed professor and director of the Oslo Mineralogical Institute in 1914 at the early age of twenty-six. A highly successful teacher, he founded a large research school both at Oslo and at Göttingen, where he moved in succession to Mügge in 1928. Many of his former pupils now hold professorships or high posts in industry, in Europe or America.

Goldschmidt resigned the Göttingen chair in 1935 as a protest against the Hitler regime, and returned to Norway. In 1942 he was sent to a concentration camp by the Germans and sentenced to deportation to Poland, but escaped to Sweden and offered his services to the Allies. He came to Britain in the spring of 1943 and worked under the auspices of the Agricultural Research Council; the first year he spent at the Macaulay Institute for Soil Research, Aberdeen, and later went to Rothamsted Experimental Station, where he remained until his return to Oslo in 1946. For some of the particulars of this notice I am indebted to Dr. W. G. Ogg of Rothamsted and to Dr. R. C. Evans at Cambridge.

Goldschmidt's researches divide themselves broadly into an early group of studies (1911–20) devoted chiefly to petrology and geology; the main group of fundamental geochemical investigations which followed from 1920; and the pioneer crystallochemical studies (1925–27) which developed naturally from them and in turn served to interpret his later work.

His researches in the field of rock metamorphism have been of the first importance. The study he made of the metamorphic aureoles around the igneous massifs of the Oslo district marked a major advance in the correlation of the chemical and mineralogical composition of thermally reconstituted rocks, and contained the first successful essay towards a systematic classification of rock mineral assemblages in the light of the phase rule. Equally important were his investigations on the zonal metamorphism of the crystalline schists of the Palæozoic mountain region of southern Norway, forming as they did a genetic study of rocks re-crystallized under shearing stress and high temperature developed during regional folding and igneous injection.

Goldschmidt's researches in geochemistry were initiated during the First World War when the deficiency of raw materials led him to extended investigations on the mineral resources of Norway. The organisation of this research was entrusted to him by the Norwegian Government in 1917, and he became chairman of the Commission for Raw Materials and director of the Raw Materials Laboratory.

After the War, with a keen research team, he applied himself with great energy to the study of the basic problem of geochemistry—the discovery of the general laws and principles governing the distribution of the chemical elements in Nature. To this end both old and new methods of chemical and physical analysis were brought to bear on the investigation of rocks and minerals. X-ray analysis and quantitative spectrographic methods provided new lines of attack, and he developed later, particularly at Göttingen, an improved technique of carbon arc spectrography.

These studies led directly to his work in crystal chemistry, the most important of his results in this field appearing in the brilliant group of memoirs published in 1925–27: "Geochemische Verteilungsgesetze der Elemente" (iv–viii). His researches on the crystal structure of ionic compounds may indeed be regarded as laying the foundation of the science of crystal chemistry. By the systematic investigation of a wide range of compounds, he was able to formulate the picture of an ionic structure as being determined primarily by the geometrical packing of ions of characteristic sizes, and to tabulate for the first time values of ionic radii for the majority of the elements. These data in their turn provided a basis for the understanding of the problems of morphotropy, and led to an explanation of the morphological relationships which exist within groups of closely related compounds and to a correlation between physical properties and crystal structure.

The principles which Goldschmidt thus established were afterwards codified more formally but without essential modification by Pauling, and have been tacitly invoked in all later work on the X-ray study of ionic structures.

The elaborate series of geochemical investigations Goldschmidt began at Oslo and continued at Göttingen have revolutionized our knowledge of the distribution of the minor constituents of the earth's crust. He demonstrated the partition of a large number of the rarer elements among the successive products of the geological cycle—from the primitive magma to the sediments and the sea—and showed that ionic size and charge are important factors controlling their ultimate sorting and concentration.

Goldschmidt's industrial work was also of great importance. He was a pioneer in the development of forsterite as a commercial refractory, now in wide use; he worked out a process for making alumina from labradorite felspar, and took part in the development of titanium pigments. His interest in agriculture arose during the First World War when Norway was faced with a shortage of potash fertilizers. He suggested the possibility of using biotite as a source of potash, and though the idea was not altogether new, the resulting experiments he developed are probably the most complete set carried out to test the possibilities.

At Göttingen in connexion with his studies of trace elements, he and his colleagues examined samples of soil and tree leaves and showed the marked relative accumulation of certain trace elements in forest litter. What was probably his last publication was an article introducing a trace element symposium in *Soil Science*.

During his stay at the Macaulay Institute and at Rothamsted, Goldschmidt was generous with his advice and took a great interest in the work of trace-element distribution.

He had for some years been engaged on a comprehensive treatise on geochemistry. It is known that the greater part of this was written before he left England, and it is confidently expected that he was able to complete it for eventual publication.

C. E. TILLEY

I wish to add to Prof. Tilley's account a few recollections of my personal relations with V. M. Goldschmidt. When he first came to Göttingen there was a latent tension between us, a mutual doubt regarding our work on ionic crystals: he considered my calculations of lattice energies cumbersome and scarcely worth while, and I had no confidence in his primitive way of adding ionic radii. But we soon discovered that these two methods were complementary, one providing exact values in a few simple cases, the other covering the whole field of crystal chemistry. After clearing the air, we became great friends. He was a remarkable man in many respects. His memory was stupendous. Once I sent an assistant to him to ask about literature on a great number of data. Instead of giving the titles of papers, he just dictated the numerical tables from memory, and a later check proved them essentially correct. He knew by heart not only the properties of atoms and ions, like radii, polarizabilities, etc., but also their occurrence in minerals and the distribution of these minerals in the earth's crust. If he did not know a fact, he had simple ways of deriving it from his radii.

Goldschmidt had a very original mind and a great sense of humour which sometimes found expression in a somewhat caustic manner. One had to take the trouble to look below the surface to discover a gentle and most generous nature which was easily wounded, and had no other defence than to hit out. To those who came to understand this, he was a devoted and most loyal friend, and they now mourn for one who has enriched their lives.

M. Born

Prof. Ludwig Jost, For.Mem.R.S.

By the death on February 22 of Prof. Ludwig Jost, Germany has lost one of its most respected botanists and science one of the leading plant physiologists. Born in 1865 at Karlsruhe, he was educated at the local *Gymnasium*. In the autumn of 1883 he commenced his studies at the University of Heidelberg, attending particularly the lectures of Bütchli and Pfitzer. Afterwards he moved to Strassburg to study under de Bary. In 1887 he took his doctor's degree there, presenting a thesis on the breathing roots of palms. In the same year he was appointed assistant to Prof. Goebel in Marburg, and later returned to Strassburg, where he acted as assistant first to de Bary and after the death of the latter to Count Solms Laubach. In 1894 he was appointed assistant professor, and in 1907 to a full professorship in the University of Strassburg. In 1919, when the French re-entered that town, he had to leave, but was lucky enough to get an appointment to the vacant professorship at Heidelberg, which he held until his retirement in 1934. He was then elected emeritus professor and continued his scientific work privately in the Kaiser Wilhelm Institute at Heidelberg, where he died, having been failing in health for some years. He was always strongly averse to the Nazi regime, and his sufferings were accentuated by the poor nutrition since the end of the War.

His varied training as a student had given him a wide outlook in botany, and his own researches touched the fields of morphology as well as those of physiology. The first edition of his lectures on plant physiology appeared in 1904 and was sufficiently appreciated to be followed by three further editions.

He won for himself a considerable reputation both at home and abroad and was elected a foreign member both of the Royal Society and the Linnean Society. His personal kindliness and his unassuming manner endeared him to all with whom he came in contact.

F. E. Weiss

We regret to announce the following deaths:

Sir Thomas Holland, K.C.S.I., K.C.I.E., F.R.S., principal and vice-chancellor of the University of Edinburgh during 1929–44, on May 15, aged seventy-eight.

Sir Frederick Gowland Hopkins, O.M., F.R.S., president during 1930–35 of the Royal Society, on May 16, aged eighty-five.

NEWS and VIEWS

Prof. E. Cartan, For.Mem.R.S.

Prof. Elie Cartan, who has just been elected a foreign member of the Royal Society, has been in the forefront of French mathematics since 1894, when his doctorate thesis on the structure of continuous groups was first published. In response to continued demand, it was reprinted forty years later. This subject has been Cartan's chief interest throughout his subsequent career as a mathematician. By 1900 Cartan had made fundamental contributions in another field, the problem of Pfaff. Two long memoirs on the subject appeared about this time in the *Annales de l'Ecole Normale*. It was in the first of these (in 1899) that he developed systematically the theory of 'exterior differential forms' which obey the laws of exterior multiplication of Grassmann. Throughout most of his subsequent work Cartan has found the method of 'exterior derivation' an extremely powerful one.

Cartan's chief contributions to the theory of relativity appeared between the years 1922 and 1925 when a systematic study of the gravitational equations of Einstein in the *Journal de Mathématique* was followed by a series of papers on relativity theory and affinely related spaces in the *Annales de l'Ecole Normale*. These last may be said to mark the beginnings of his major contributions to differential geometry, where he has found the method of the moving trihedron (*repère mobile*) of dominant significance. The essential unity of Cartan's ideas in different branches of mathematics is well illustrated by a tract which he published in the "Actualités" series in 1935, in which he shows that the theory of the moving trihedron has an intimate connexion with the equations of structure of a continuous group, and that the equations of structure of a group G contain in themselves all the differential geometry of the space having G as fundamental group.

Organic Chemistry at Edinburgh: Prof. E. L. Hirst, F.R.S.

Prof. E. L. Hirst, at present Sir Samuel Hall professor and director of the Chemical Laboratories in the University of Manchester, has been appointed to the newly instituted Forbes chair of organic chemistry in the University of Edinburgh. Prof.

Hirst, who was born in 1898, was educated at the Northgate School, Ipswich, and Madras College, St. Andrews. After graduating M.A. in Latin, Greek and logic at the University of St. Andrews, Hirst proceeded there to the degrees of B.Sc. and Ph.D. in chemistry under Prof. (later Sir) J. C. Irvine. While at St. Andrews he made notable contributions to the chemistry of cellulose and the structure of simple sugars. He was an assistant in chemistry at St. Andrews during the brief professoriate of (Sir) Robert Robinson, and moved with him to Manchester. In 1924 Hirst was appointed lecturer in Armstrong College, University of Durham, where Prof. (now Sir) Norman Haworth, with whom he had worked in St. Andrews, had established a school of carbohydrate chemistry. Haworth was appointed to Birmingham in 1925, and in the following year Hirst followed him; Hirst was appointed reader in the chemistry of natural products in 1935. This period marked a tremendous advance in carbohydrate chemistry, when the ring forms of sugar and glycosides were given precise definition, the constitution of all the important disaccharides was established, and great advances in the chemistry of starch, glycogen and cellulose were made. Hirst's most spectacular work at this time was the determination of the constitution of ascorbic acid (vitamin C) and its synthesis (in association with Haworth), representing the first laboratory synthesis of a vitamin.

In 1936, Prof. Hirst was elected Alfred Capper Pass professor of chemistry in the University of Bristol; here he continued and extended his studies on carbohydrates to such highly complex bodies as pectins, plant gums and mucilages, and threw further light on the constitution of starch. This work was interrupted during the recent War, when all academic research at Bristol was discontinued. Hirst was appointed head of the Bristol Outstation Armament Research Department. He served on the Scientific Advisory Committee of Research and Development of the Ministry of Supply, and was chairman of the Explosives Committee (Chemistry) and of various panels during the period of hostilities. Since Prof. Hirst's appointment to the Manchester chair in 1944, his work has been mainly concerned with the development of new methods for end-group determinations for use in dealing with the problems of the structure of complex polysaccharides. Hirst served as an independent member of the Working Party for the Cotton Industry, and was chairman of its research sub-committee.

Dr. K. Mellanby, O.B.E.

Dr. K. Mellanby, who has been announced as principal designate of the new University College which it is proposed to establish in Nigeria, has had a varied career. Trained at Cambridge as a zoologist, he devoted himself in the years before the War to the study of insect physiology. First, at the London School of Hygiene and Tropical Medicine and in Uganda he did illuminating work on the water relations of insects. As Sorby Research Fellow of the Royal Society he transferred to Sheffield and studied particularly the adaptation of insects to cold, both in the laboratory and in the field—in arctic Finland. At the outbreak of the War, Dr. Mellanby's organising ability became apparent. A survey of the incidence of head-lice among children in fever hospitals throughout the country gave the first accurate picture of the distribution of pediculosis in Britain. Dr. Mellanby then turned to the scabies problem. Enlisting the co-operation of a team of 'conscientious objectors' to serve as experimental subjects, he was able to carry out a fine scientific and practical study of scabies which placed our knowledge of the incidence and spread of the itch mite and the efficacy of the various treatments on a really sound basis. The well-known film of this work was a valuable piece of propaganda.

After a period as scientific liaison officer in North Africa, Dr. Mellanby joined the team organised by the Medical Research Council to investigate the spread of scrub typhus. His particular province was the ecology of the mites which carry the disease; but he again put great energy into the propaganda side of the work, including the preparation of an instructional film. Extensive travel in America, Australia and the Pacific area provided more valuable experience. In 1945 he was appointed reader in entomology at the London School of Hygiene and Tropical Medicine. Dr. Mellanby's wide knowledge of the world, his organising ability and a gift for getting on well with all sorts of people promise success to this new venture.

Government Estimates for Scientific and Industrial Research

The Civil Estimates for the year ending March 31, 1948, now published (Class VI) show a gross estimate of £3,449,375 for the Department of Scientific and Industrial Research, against which appropriations in aid amount to £331,086, the net increase on 1946–47 being £727,355. Grants for investigation and research are estimated at £1,182,000, an increase of £254,4.. on 1946–47, of which £842,000 is represented by annual grants to research associations and bodies engaged in industrial research, and £240,000 by grants to students and other persons or bodies engaged in scientific research. Headquarters expenditure is estimated at £175,780 as against £129,604 in 1946–47, and the estimate for the National Physical Laboratory shows an increase from £423,180 to £489,459, with an increase in staff from 611 to 731. The estimate for the Chemical Research Laboratory is increased from £42,158 in 1946–47 to £57,753, with an increase in staff from 58 to 102. Expenditure on the Building Research Station is estimated at £192,390 as against £151,380, with an increase in staff from 255 to 374; on food investigation at £88,803 as against £78,365, with an increase from 111 to 136 in staff; on the Forest Products Research Laboratory at £69,929 as against £61,913, with an increase in staff from 77 to 112; on fuel research at £164,676, as against £137,340, with an increase in staff from 174 to 232; on the Pest Infestation Laboratory at £22,444 as against £19,386, with an increase in staff from 43 to 52; on the Road Research Laboratory at £152,929 as against £97,850, with an increase in staff from 147 to 233; and on the Water Pollution Research Laboratory at £29,754 as against £22,058, with an increase in staff from 51 to 74. The total staff is estimated at 2,129 as against 1,538 in 1946–47. For the Geological Survey and Museum of Practical Geology, expenditure is estimated at £187,704 as against £106,941.

This net total of £3,118,289 represents only a part of the Treasury contribution to research for the current year. In addition to the vote of £12,000,000 to the universities, part of which at least will be expenditure on research, the Civil Estimates include appropriations of £698,000 for the Medical Research Council, £400,000 for the Agricultural Research

Council, £1,977,450 for agricultural education and research under the Ministry of Agriculture and Fisheries, and £412,652 for agricultural research and experiments under the Department of Agriculture for Scotland; £144,450 for fisheries research, £374,000 for forestry research and education, £78,623 for fisheries research and development in Scotland, £500,000 for Colonial research, and £50,000 for the social survey. Miscellaneous grants in aid of scientific investigation include £53,000 to the Royal Society. The grand total is approximately £19,500,000. Although the Dominions Office vote includes a grant of £33,825 in aid of Imperial Economic and Research Services, and the Ministry of Food vote £4,500,000 for the production of ground-nuts in East and Central Africa, of which some small fraction is for research, it is unlikely that the total expenditure from the Exchequer in aid of civil research much exceeds £10,000,000 for the current year as against the £60,000,000 to be expended by the Ministry of Supply and the Admiralty, apart from the work which may be carried out by the Department of Scientific and Industrial Research for the Services.

Atomic Power in Sweden

THE Swedish Atomic Committee, which consists of ten leading men of science and technicians, has submitted a proposal to the Swedish Government, recommending the formation as soon as possible of a joint-stock company, AB Atomenergi, with a capital of about £241,000, of which about two thirds would be contributed by the State and the remainder by Swedish industry. The first task of the company would be to design and build an experimental plant for the liberation of atomic energy, and later on a plant for the production of atomic power on an industrial scale would be erected. The Committee also suggests that, in addition to 2,000,000 kronor already proposed in the current State budget, another 2,000,000 kronor should be appropriated for research work to be performed under the supervision of a new body, the Atomic Research Council. It is reported that the company will use uranium from shale deposits in the central Swedish provinces of Närke and Västergötland.

Suggested British Herpetological Society

AT an informal meeting held at the British Museum (Natural History) on April 10 the formation of a British Herpetological Society was considered. The Society would be formed with the view of increasing our present knowledge and promoting interest in various aspects of herpetology which, it is felt, have been somewhat neglected. Its main objects would be: (1) to encourage the study of the ecology, life-histories, habits and distribution of the Amphibia and reptiles, and of the British species in particular; (2) to publish annually a report on the work of the Society, and to review briefly advances in knowledge, particularly in the field of ecology; (3) to hold meetings, when possible, for the reading of papers and the discussion of problems relating to herpetology; (4) to record and compile information on the various aspects of the subject covered by the Society. Although such a Society would, of necessity, be concerned mainly with the study of British species, foreign membership would be most welcome. It is suggested that the annual subscription to the Society, including a free copy of the report, should be ten shillings. Those interested in the formation of such a Society should communicate with Capt. J. D. Romer, 96 Mortlake Road, Kew, Surrey. If the response is sufficiently large, further steps will be taken to inaugurate the Society, and individuals will be informed accordingly.

Association of Social Anthropologists

AN Association of Social Anthropologists was founded on July 23, 1946, in response to the general opinion among social anthropologists in Great Britain that the subject has reached a stage of development warranting the establishment of a professional organisation. Its objects are to promote the study and teaching of social anthropology as a specialized branch of anthropology; to represent the interests and maintain the professional standards of the subject; to arrange periodic conferences of the members of the Association; and to secure publication of researches under its auspices. It is intended to publish a journal, *Annals of Social Anthropology*, as soon as arrangements can be made.

The Association includes teachers and senior research workers in social anthropology in the British Empire. Membership is limited to persons holding, or having held, a teaching or research appointment in social anthropology, and is strictly by invitation of the officers and committee of the Association. The present officers and committee are: Prof. A. R. Radcliffe-Brown (president), Prof. E. E. Evans-Pritchard (chairman and hon. secretary), Prof. Raymond Firth, Prof. C. Daryll Forde and Dr. Meyer Fortes.

Iraq Natural History Museum

THE first Natural History Museum in Iraq, which is under the auspices of the Iraqi Ministry of Education, was established early in 1946. The formal opening by the Regent of Iraq took place on May 2, 1946. The Museum consists of three main departments at present. (1) Zoological Department: the present exhibits in this department represent most of the avifauna of Iraq, as well as small collections of Iraqi mammals, reptiles, fishes and invertebrates. (2) Botanical Department: in this department plaster models of Iraqi fruits and vegetables are exhibited. There are also specimens of plant products, economic plants, plant diseases, etc. (3) Geological Department: in this department two of the oil companies operating in the country have participated in presenting its exhibits. The Iraq Petroleum Co. presented a cement model of the geological structure of the Kirkuk oilfields, as well as specimens of rocks, crude oil, and fossils found in Iraq. The Rafidain Oil Co. presented a model of an oil refinery, specimens of oil products, a model of a Leyland motor oil-tanker, a lubricating oil unit, a petrol filling pump, and various photographs and diagrams. The Museum is seeking to establish contacts with similar museums elsewhere, and to exchange information and publications with them. All communications should be addressed to the Director, Iraq Natural History Museum, Baghdad, Iraq.

British Society for the History of Science

AT the first annual general meeting of the British Society for the History of Science, held in the rooms of the Royal Society on May 5, the following elections of officers and council were made: *President*, Dr. Charles Singer; *Vice-Presidents*, Prof. H. Dingle, Dr. E. J. Holmyard, Sir Arthur MacNalty, Prof. J. R. Partington, Mrs. Charles Singer, Dr. Sherwood

Taylor; *Hon. Secretary*, F. H. C. Butler; *Hon. Treasurer*, H. W. Robinson; *Council*, Dr. H. P. Bayon, Prof. G. R. de Beer, C. N. Bromehead, J. G. Crowther, Dr. Dorothy Feyer, Dr. S. Lilley, Dr. D. McKie, H. T. Pledge, Dr. H. Shaw, Dr. H. Hamshaw Thomas, Sir Henry Thomas and Dr. E. Ashworth Underwood. The address of the honorary secretary is: Ravensmead, Keston, Kent.

Colonial Medical Research Studentships

On the recommendation of the Colonial Medical Research Committee, the Secretary of State for the Colonies has instituted ten research studentships for graduates in medicine and cognate sciences, who desire by this means to prepare themselves for research work in tropical medicine and related subjects. The Studentships will carry an allowance at the rate of £260 per annum, and will normally be for a period of two years. They will be awarded on the advice of the Colonial Medical Research Committee, and will be tenable at any university or other appropriate institution as approved by the Committee. Candidates must be British subjects and graduates of British universities. Application should be made, through the head of the candidate's department, to the Secretary, Colonial Medical Research Committee, c/o Research Department, Colonial Office, London, S.W.1.

Textile Institute

The Textile Institute is offering a scholarship, under the terms of a grant from the Cotton Trade War Memorial Fund, to young craftsmen in the cotton spinning or weaving industry, and is planning an additional award for those who have not yet entered the industry. The scholarship will extend for not more than three years, and is of a maximum value of £200 prior to the final year, and £350 for the final year, during which it will provide the holder with practical experience abroad. Forms of application can be obtained from the General Secretary, Textile Institute, 16 St. Mary's Parsonage, Manchester 3; applications are to be made by July 1.

Prof. Fred Bradbury, formerly head of the Department of Textile Industries at Belfast College of Technology, has been elected to honorary life membership of the Textile Institute. Prof. Bradbury took part in the formation of the Institute thirty-seven years ago, and was a member of the Institute's first Council elected in 1910.

Congresses

International Congress on Short-Wave Therapeutics

An International Congress on Short-Wave Therapeutics will be held in Amsterdam during July 19–24, 1948. Formal papers followed by discussions are being arranged. Particulars can be obtained from the Secretary of the Congress, Weteringschans 73, Amsterdam.

International Congress on Engineering Education

Prof. Richard Vieweg and Prof. Alwin Walther, with a small group of staff of the Darmstadt Technische Hochschule, are now trying to rebuild the college both as regards its buildings and its standing. They are accordingly organising, with the approval of the American Military Government, an International Congress on Engineering Education, to be held at Darmstadt during July 31–August 9. Feeding and housing of conference members from outside Germany will be undertaken by the American quartermaster's school at Darmstadt; suitable provision will also be made for Allied visitors from the other occupation zones. Darmstadt Technische Hochschule and the city of Darmstadt will furnish accommodation for Germans who attend. The preliminary programme indicates the following topics for discussion: (1) technology as an ethical and cultural opportunity; (2) present state and trends of development in engineering education throughout the world; (3) admission of students in relation to social problems; (4) exchange of professional ideas. Further information can be obtained from the Rector, Technische Hochschule Darmstadt, Kongressleitung, Darmstadt, U.S. Zone, Germany.

Announcements

Sir Robert Robinson, Waynflete professor of chemistry in the University of Oxford and president of the Royal Society, has been awarded the Albert Medal of the Royal Society of Arts "for his outstanding contributions to the advancement of organic chemistry".

Under the Statute of the Royal Society which provides for the election of persons who either have rendered conspicuous service to the cause of science or are such that their election would be of signal benefit to the Society, Mr. Clement R. Attlee has been elected a fellow of the Society.

Dr. John B. M. Coppock, head of the Technical Development Laboratories of the Fine Chemical Department, Boots Pure Drug Co., Ltd., Nottingham, has been appointed director of research of the recently formed British Baking Industries' Research Association.

Dr. F. N. Woodward has been lent to the Department of Scientific and Industrial Research for appointment as director of the United Kingdom Scientific Mission in the British Commonwealth Scientific Office in Washington. The present director, Dr. Alexander King, is shortly returning to the United Kingdom to take up an official appointment. Dr. Woodward is at present director of the Scottish Seaweed Research Association; during the War he was on the scientific staffs of the Ministries of Supply and Production. Dr. Woodward will also act as attaché for scientific questions to the British Embassy in Washington.

The Council of the University of Sheffield has made the following appointments: G. L. Hermitte, to be lecturer in histology; F. T. Thorpe, to be lecturer in mental diseases; R. M. Haythornthwaite, to be lecturer in civil engineering.

Mr. J. G. Pearce, director of the British Cast Iron Research Association, writes to point out that in the article in *Nature* of May 10, p. 649, on the Birmingham conference of the Federation of British Industries, the last sentence of the remarks attributed to him may give rise to misunderstanding. The full text was: "Of the major functions of a research association, the creation of new knowledge by research, its application in a given case through development, and its dissemination by intelligence activities, the problems of development and dissemination have been least satisfactorily solved . . ."

Erratum. In the communication "Nucleotide Metabolism of Bacteria and the Bacterial Nucleus" in *Nature* of April 26, p. 577, the illustration was inadvertently printed upside down.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Atomic Mass of Silicon

As is well known, the atomic mass of silicon has not yet been determined with satisfactory accuracy. The value given in the International Table of Atomic Weights is 28·06. Practically the same value, 28·063, was given by Baxter, Weatherill and Scripture[1] in 1923 from the ratio $SiCl_4/4Ag$. But from the same ratio, figures of $28{\cdot}11_1$ had been obtained in 1920 by Baxter, Weatherill and Holmes[2] and of $28{\cdot}10_5$ by Hönigschmidt and Steinheil[3]. Finally, in 1923, Weatherill and Brundage[4], from the ratio $SiCl_4/SiO_2$, gave the value $28{\cdot}10_6$. The three of the four modern gravimetric values are in fair agreement and lead to a mean figure of $28{\cdot}10_4$, which exceeds by 1/610 approximately the figure given in the International Table. This difference, considering the precision of modern gravimetric methods, is too great to be accepted without reservations, and it makes desirable and urgent a further revision of the atomic mass of silicon.

For this reason the recent publication of the experiments carried out by E. P. Ney and McQueen[5] with the mass-spectrograph on the isotopes of silicon must be welcomed. Subjecting silicon fluoride to an electronic bombardment, several ions are produced, among which the group SiF_3^+ is particularly interesting, from which it was possible to measure the mass and the abundance of the three isotopes, ^{28}Si (92·24 ± 0·10); ^{29}Si (4·69 ± 0·05) and ^{30}Si (3·07 ± 0·05). From these data, Ney and McQueen give the value of the atomic mass of silicon as 28·087, exceeding by 1/1039 the figure accepted by the International Commission.

The revision of the atomic mass of silicon has been undertaken at the Laboratory of Physical Chemistry of Compostela (Spain) using the pykno-X-ray method. This method, applied for the first time by Hutchison and Johnston to the determination of the atomic mass of fluorine[6], is based on the comparison of the molecular mass of the substance with that of calcite. The molecular mass of a crystal depends on: (*a*) the volume of its unit cell; (*b*) the number of molecules contained in the latter; (*c*) its density (ρ); and (*d*) Avogadro's number (N_A); hence when these values are known—at a given temperature—for the substance and the calcite, a simple formula enables the atomic mass to be calculated.

The compound chosen for the revision of the atomic mass of silicon was silica (SiO_2), in the form of α-quartz of hexagonal structure, the X-ray constants of which accurately determined by A. H. Jay[7] at 18° C. are: $a = 4{\cdot}9029$ A., and $c = 5{\cdot}3933$ A. As regards density, the pykno-metric measurements at 0° C., carried out by C. Gutierrez Losa in this Laboratory using our precision technique[8] with very pure transparent quartz from Noya (Corunna, Spain) give the mean value: $\rho_4^0 = (2{\cdot}6506_9 \pm 0{\cdot}0002_3)$ gm./cm.^{3}. Taking as coefficient of cubic expansion of α-quartz[9] the value $3{\cdot}529 \times 10^{-5}$, the density of SiO_2 at 18° C. will be: $\rho_4^{18} = (2{\cdot}6490_6 \pm 0{\cdot}0002_3)$ gm./cm.^{3}. As regards calcite, I have taken as molecular mass, $M_{CaCO_3} = 100{\cdot}090$, and as density, grating space and geometric structural constant, $\varphi(\beta)$, at 18° C., the values given by Bearden and Bearden and Shaw[10]: $\rho_4^{18} = 2{\cdot}71036$ gm./cm.^{3}, $d^{18} = 3{\cdot}02945$ A., and $\varphi(\beta) = 1{\cdot}09598$.

From the equations,

$$M_{SiO_2} = \frac{\sqrt{3}}{6} \cdot N_A \cdot \rho_{SiO_2} \cdot a^2 \cdot c$$

and

$$M_{CaCO_3} = 2 \cdot N_A \cdot \rho_{CaCO_3} \cdot \varphi(\beta) \cdot d^3_{CaCO_3},$$

and expressing the molecular mass of SiO_2 and $CaCO_3$ as a function of the other magnitudes mentioned, we conclude

$$M_{SiO_2} = M_{CaCO_3} \cdot \frac{\sqrt{3}}{12} \cdot \frac{\rho_{SiO_2}}{\rho_{CaCO_3} \cdot \varphi(\beta)} \cdot \frac{a^2 \cdot c}{d^3_{CaCO_3}}.$$

Substituting in this equation the various numerical values, we find $M_{SiO_2} = 60{\cdot}075$, the atomic mass of silicon being, therefore,

$$Si = 28{\cdot}075.$$

This determination is based on the molecular mass of calcite. This may not be the best reference substance for our purpose, since "it is well known to crystallographers that calcite always contains impurities"[11], and also because in the value of its molecular mass there is an approximate error of ± 0·007. On this account it is advisable, in my opinion, to take as reference substance sodium chloride, the molecular mass, density and grating space of which have been accurately determined. From

$$M_{NaCl} = 2N_A \cdot \rho_{NaCl} \cdot d^3_{NaCl}$$

it can be deduced that

$$M_{SiO_2} = M_{NaCl} \cdot \frac{\sqrt{3}}{12} \cdot \frac{\rho_{SiO_2} \cdot a^2 \cdot c}{\rho_{NaCl} \quad d^3_{NaCl}}.$$

Taking as molecular mass, $M_{NaCl} = 58{\cdot}454$, as density, at 18° C., the figure given by Johnston and Hutchison[12], $\rho_4^{18} = 2{\cdot}16396$ gm./cm.^{3}, and as grating space, $d^{18} = 2{\cdot}81425$ A., and substituting these figures in the above equation, we obtain $M_{SiO_2} = 60{\cdot}076$, or Si = 28·076, in good agreement with the figure obtained taking calcite as reference. The mean value of the two atomic masses thus found,

$$Si = 28{\cdot}075,$$

is somewhat lower than the value found by Ney and McQueen, but higher than the one accepted by the International Commission. The most recent determinations seem, therefore, to suggest that the atomic mass of silicon is slightly higher than the one still given in the International Table.

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March 7.

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[2] Baxter, Weatherill and Holmes, *J. Amer. Chem. Soc.*, **42**, 1194 (1920).
[3] Hönigschmidt and Steinheil, *Z. anorg. Chem.*, **141**, 101 (1924).
[4] Weatherill and Brundage, *J. Amer. Chem. Soc.*, **54**, 3932 (1932).
[5] Ney, E. P., and McQueen, *Phys. Rev.*, **69**, 41 (1946).
[6] Hutchison, C. A., and Johnston, H. L., *J. Amer. Chem. Soc.*, **63**, 1580 (1941).
[7] Jay, A. H., *Proc. Roy. Soc. Lond.*, A, **142**, 237 (1933).
[8] Batuecas, T., and Casado, F. L., *J. Chim. phys.*, **33**, 41 (1936); *Z. phys. Chem.*, A, **181**, 197 (1938); *Bol. Univ. Santiago de Compostela* (Oct.–Dec., 1935).
[9] "International Crit. Tab", **4**, 21 (1928).
[10] Bearden, *Phys. Rev.*, **36**, 2089 (1931). Bearden and Shaw, *Phys. Rev.*, **48**, 18 (1935).
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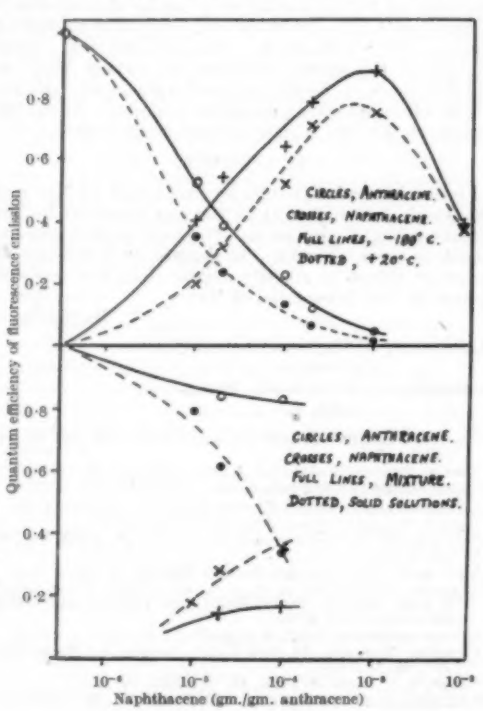
Fluorescence of Solid Anthracene

THE fluorescence of solid anthracene in light of wave-length 3650 A. is changed from blue to green when very small quantities of naphthacene are present in solid solution. This is explicable by an 'exciton' mechanism whereby energy is handed on by resonance from molecule to molecule[1]. The graphs shown here represent a quantitative examination of the effect, the blue and green components of the fluorescence being measured by a photo-cell through Ilford filters 601 and 404 respectively. The upper graph shows for two temperatures the fall of the blue anthracene fluorescence and the rise of the green naphthacene fluorescence with concentration of the latter, expressed as quantum efficiencies with a probable error of 15 per cent. The emissions are about equal at a naphthacene concentration of 3×10^{-5}, and the green reaches a maximum at about 10^{-3}. Above this concentration the colour of the emission changes to yellow as for pure naphthacene, and the efficiency decreases, evidently due to the overstepping of the limits of solid solution.

The supposed 'exciton' effect cannot be due to direct light absorption by the naphthacene owing to its feeble absorption at 3650 A. To eliminate the possibility that re-absorption of blue anthracene fluorescence followed by re-emission as naphthacene fluorescence is the cause, solutions of anthracene and naphthacene in acetone were poured into aqueous gelatine solutions to produce milk-like sols the fluorescence of which could be measured under conditions of feeble light absorption. The lower graph shows as dotted curves the blue and green intensities for anthracene – naphthacene sols precipitated from one solution. These do not differ greatly from the curves of the upper graph for solid solutions made by fusion. The full lines, however, relate to anthracene – naphthacene concentrations made by mixing separately prepared sols of pure anthracene and of anthracene – naphthacene mixtures of concentration 10^{-3}. The differences for homogeneous and non-homogeneous mixtures of similar composition are strong evidence in favour of the 'exciton' hypothesis.



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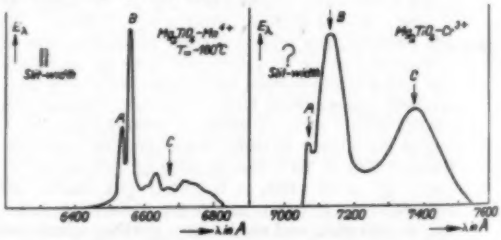
[1] Bowen, E. J., *Nature*, **153**, 653 (1943); *J. Chem. Phys.*, **13**, 306 (1945).

Tetravalent Manganese as an Activator in Luminescence

THE fluorescence of luminophors activated with manganese, and also of pure manganese compounds, is generally attributed to divalent manganese[1]. The spectra emitted vary between green and red, and the width of the bands also varies from case to case, both probably being dependent on the magnitude and the symmetry of the electric lattice field at the position in the lattice at which the manganese ion is placed.

There is no doubt that this explanation is correct for the greater part of the manganese fluorescence known, and the colour differences between the green and red fluorescence respectively of zinc and magnesium silicates activated with manganese are certainly not due to differences in the valency of the manganese.

We have found some systems, however, in which also manganese of a higher valency can cause fluorescence. The emission due to these ions is situated in the red and shows a fine structure which is unusually sharp for manganese phosphors. In these systems, namely, zinc aluminate, magnesium aluminate, α- and β-aluminium oxide and magnesium titanate, all activated with manganese, the luminescence is markedly different according as the products are prepared under oxidizing or reducing conditions. The reduced products (except the titanate) show a green cathodo-luminescence. This emission is due to divalent manganese. The oxidized products show a deep red luminescence upon excitation by cathode rays or long-wave ultra-violet (3650 A.)[2]. This red fluorescence is due to manganese of a higher valency. In magnesium titanate the valency could be determined by chemical methods (titration), and was found to be between 3 and 4. That it is tetravalent manganese which is responsible for the red emission can further be proved by comparing the spectral distribution of the fluorescence of the salt when activated with manganese and with trivalent chromium respectively[3].



FLUORESCENCE SPECTRA OF Mg_2TiO_4—Cr^{3+} ACCORDING TO DEUTSCHBEIN (*loc. cit.*) AND Mg_2TiO_4—Mn^{4+}

The fluorescence spectra of these two substances (see graph) show a resemblance such as is to be expected for emissions which are characteristic of the iso-electronic ions Cr^{3+} and Mn^{4+} (both having a d^3 configuration) in the same surroundings[4].

Detailed results with these systems, including absorption, emission and excitation spectra, and the chemical methods used to obtain products with a maximum fraction of tetravalent manganese, will be published elsewhere[5].

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[1] Randall, J. T., *Proc. Roy. Soc.*, A, **170**, 272 (1939). Kröger, F. A., *Physica*, **6**, 764 (1939); Dissertation, Amsterdam, 1940. The arguments brought forward by Uehara, Y., *J. Chem. Soc. Japan*, **61**, 741 (1940), in favour of atomic manganese, are not very convincing.

[2] The same applies also to manganese-activated strontium aluminates which have recently been patented (Froelich, H. C., U.S.A. Pat. 2,392,814).

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Marine Seismic Prospecting

IN the years immediately preceding the War, considerable progress was made in the use at sea of the seismic method of studying submarine geology, and work was carried as far as the 100-fathom line. Further progress to deeper water was rendered difficult by the troubles arising in putting the instruments and explosives on the bottom of the sea. As a result of work in 1938 and 1939, it was suggested[1] that it might be possible to avoid these difficulties by having the instruments hanging in the water and relying on the transmission of the seismic waves from the bottom into the water. Unpublished observations during the War, both in Great Britain and in the United States, showed that seismic waves could, in fact, be observed in this way. In order to test the possibilities of the method, a direct comparison has been made of the signal received by a geophone on the bottom and by a hydrophone in the water. The explosive was also hanging in the water.

A calibrated moving-coil geophone, damped to give a constant velocity response from 30 to at least 100 c./s., was laid on the bottom with its axis approximately vertical. Its output was compared with that of a calibrated quartz-crystal hydrophone sensitive only to pressure changes, which was suspended about 40 ft. below the ship, and which had a flat response from 5 c./s. upwards.

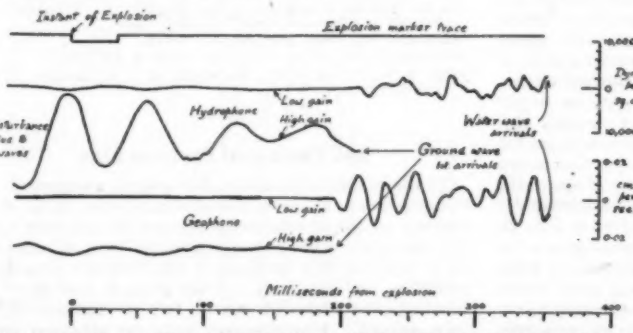
The output of each instrument was recorded at two levels of sensitivity, using four of the six strings of an Einthoven galvanometer. A fifth string was used to record the instant of explosion, so that the distance of the shot point could be determined from the transmission time of the direct wave through the water. Charges of 1–2 lb. of 'Polar Geobel', fired 100 ft. below the surface, gave satisfactory records up to 800 yards. A tracing from one of the records is shown in the figure. In this record the overall gain was adjusted so that the background-levels were visible on both high-gain strings, while the low-gain channels had about 24 db. less sensitivity. Under these conditions, the first arrival of the ground-wave was of sufficient amplitude to throw the high-gain strings off scale, while the direct water-wave produced a similar break in the low-gain traces. There was a considerable swell running when this record was taken, and the wind velocity was about 25 knots.

The charges used in the earlier experiments were attached to a buoy, fired by clockwork, and the instant of detonation transmitted to the ship by radio. This method was rendered cumbersome by the impossibility of controlling the instant of detonation after the buoy had been launched, and by the need for somewhat elaborate safety precautions. In most cases, therefore, the charge was trailed on an electric cable with floats every 100 yards. This method, while convenient at short ranges, could not easily be extended to distances greater than a few miles because of the labour of recovering the cable. For long-range work, it would be preferable to use a separate ship to fire the charge, as in the pre-war work, or to attach the hydrophone to a radio buoy which would transmit the signal back to the firing ship.

Difficulty arose from the transmission of mechanical disturbances down the instrument cables, but for the hydrophone this was overcome by giving the instrument a slight positive buoyancy, and by attaching a sinker about 30 ft. from the end of the cable. The geophone cable was similarly weighted, and the ship was allowed to drift freely during the recording period. Just before the shot, the geophone and weight were lowered to the bottom, and cable was paid out to allow for the movement of the ship. Under these conditions, the arrivals of the ground-wave were well defined, and the ratio of pressure to velocity agreed to within a factor of 2 with the theoretical value for plane waves in an infinite medium. Closer agreement was not to be expected, as the result was affected by reflexions from the surface, and by deviations of the geophone axis from the wave normal.

There seems no reason why this method should not be used in the deep ocean, and it appears to possess great practical advantages over any other that has been suggested.

The assistance of the Director of the Marine Biological Association at Plymouth for the laboratory and shipping facilities, and of the



RECORD SHOWING A COMPARISON BETWEEN THE SIGNALS PRODUCED BY A GEOPHONE AND A HYDROPHONE FROM THE SEISMIC WAVES RESULTING FROM AN UNDERWATER EXPLOSION

Superintendent of the Admiralty Mining Establishment for the loan of the hydrophones and other apparatus, is gratefully acknowledged.

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March 28.

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A New Method for the Observation of Zones of Colourless Substances on a Chromatographic Column

When chromatographic adsorption analysis is used for colourless substances (or on strongly coloured adsorbents, for example, activated carbon) it is impossible to see the zones of the different solutes adsorbed on the column. Some special arrangement is then needed in order to be able to locate the zones. In principle, two methods are available: (1) no observation is made on the column, but instead the concentration of the solution leaving the column is followed in a small cell; (2) the positions of the zones on the column are determined by using some special physical or chemical properties of the solutes. The first method, which was introduced by Tiselius[1] and improved by Tiselius and me[2,3], has also the advantage that the separation between two adjacent zones is greater in the filtrate than on the column. However, in many cases it is of importance to follow the separation directly on the column, and a number of different arrangements have been proposed[4]. In most of these cases the solutes either are converted into coloured compounds by means of suitable reagents, or indicators are applied before or after the chromatogram is finished, or use is made of fluorescence methods. These methods are, however, limited in use and unsuitable when zones are in direct contact with each other.

The new procedure to be described can be applied quite generally. The zones are detected on the column by observing the changes in refractive index of the solution in contact with the particles of the adsorbent. It is quite clear that this can be followed by any method for the determination of refractive index which uses the total reflexion of light entering through the glass wall of the tube in which the adsorbent is packed.

One of the simplest arrangements for the observation is the following. A tube with rectangular cross-section is used for the adsorbent (Fig. 1). Such a tube can easily be made by clamping two glass windows against a U-shaped plate of metal. One of the windows is rather thick and has polished edges. If the adsorbent is observed at the proper angle (Fig. 1) from a suitable distance (*c.* 1 metre), the boundary of the region of total reflexion is easily seen, and its position depends on the refractive index of the solution wetting the glass. Its shape will, therefore, be as in Fig. 2*a* in the case of an ordinary chromatogram with separate zones, and as in Fig. 2*b* if frontal analysis or displacement development is used. With strongly coloured adsorbents it may sometimes be useful to place a strip of thin white paper between the adsorbent and the glass window.

The operation of this method is in principle equivalent to that of a Pulfrich refractometer. It is clear that the sensitivity is improved by using monochromatic light during the observation. If necessary, the method can also be made quantitative by measuring the angle α with a telescope, since

$$n_0^2 - n_1^2 = \sin^2\alpha,$$

where n_0 is the refractive index of the glass and n_1 that of the solution. The accuracy can, of course, also be increased by using more elaborate methods for the observation; for example, an arrangement equivalent to a Hallwach's cuvette[5].

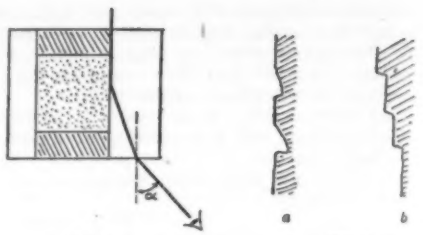

Fig. 1 Fig. 2

Fig. 1. Tube for chromatography seen from above
Fig. 2. Shape of total reflecting region for (*a*) elution analysis, (*b*) frontal analysis

This method has the advantages that it can be applied quite generally and is independent of the specific properties of the solutes. Furthermore, it can be used when zones containing very similar substances with increasing concentration are in contact with each other, as in frontal analysis and displacement development. It seems also to be quite useful for inorganic chromatography. In the case of very large columns it is only necessary to place a strip of plane parallel glass in the wall of the container. It is also worth while to point out that different areas with different refractive indices can be detected in the same way when paper chromatography[6,7] is used, by placing the paper under the glass.

Although the method has the disadvantage that it is not so sensitive as most of the colour reactions, it does not exclude other kinds of observation, since the column can be observed in the usual way through the windows. Some experimental applications of the above principle will be reported later.

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Gates and Crellin Laboratories of Chemistry,
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Feb. 28.

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Set Time and Particle Size

In dissolving high-molecular weight compounds in hydrocarbons to give viscous solutions, it is convenient to stir or otherwise agitate the mixture until the viscosity of the solvent is raised to such a degree as to prevent any settling of the partially dissolved particles on standing. After such a 'set time' is reached, the material can be left to dissolve on its own accord. Homogeneity may be attained by a final shaking or mixing.

Set time as described above is a complex phenomenon governed by several factors. However, it is possible to correlate set time and particle size by a simple functional equation on the assumption that the method of attaining solution is standardized.

For any particle, the representative dimension of which is L, the viscosity, μ, is given by

$$\mu \propto L^{s},$$

where μ is the viscosity of the solution required to give a standard rate of settling of the swollen particle the original dimension of which was L. This expression still holds for set time, T, defined as the time when the rate of fall of the swollen particle reaches a low standard value, which is undetectable over a period of one minute by the naked eye.

The viscosity of the colloidal solution can be given by the approximate proportionality, connecting μ and C, the concentration :

$$\mu \propto C^{n},$$

where n is a variable index approaching 1 at zero concentration and has been found to be as high as 8 at high concentrations of macromolecules in hydrocarbons. Thus :

$$C \propto \sqrt[n]{L^{s}}.$$

If the rate of solution, R, is approximately constant, due to stirring under standard conditions, then it is reasonable to put R as proportional to the specific surface of the particle per unit volume, that is,

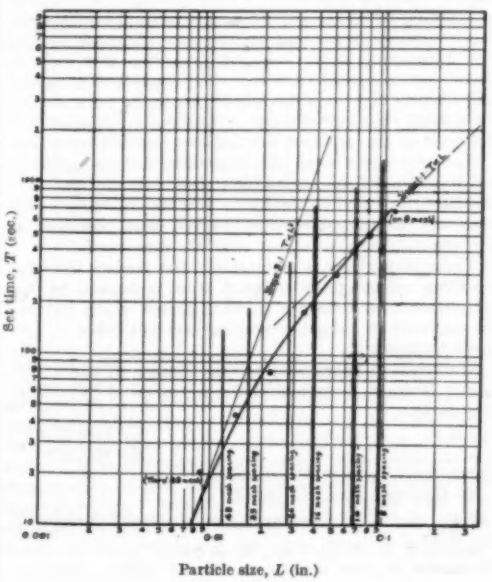
$$R \propto 1/L.$$

Thus set time T will be reached when solution at the rate R yields a concentration C :

$$T = C/R \propto CL \propto L^{(1+2/n)}.$$

Thus for low concentrations ($n = 1$), T will be proportional to the cube of the representative dimension of the particle ; for high concentrations T is approaching a linear proportionality with L. As small particles require low values of C and large particles require high values, in order to be settling at undetectable rates, it follows that a plot of log T *vs.* log L should give a curve with log T varying with log L, so that $d(\log T)/d(\log L)$ is 3 at low values of L and unity at high values of L.

The accompanying graph gives the curve obtained for a series of sizes of a soap of aluminium. The agreement shown appears to justify the several assumptions made.



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Absorption of Hydrogen by Aluminium Attacked in Caustic Soda Solution

In some experiments reported recently by Moreau and Chaudron[1], it was found that prolonged immersion of high-purity aluminium in dilute (N/100) caustic soda solution resulted in the absorption of large quantities of hydrogen by the metal, and that the presence of this gas had a measurable effect upon the elastic modulus. After 20–30 days immersion, the hydrogen content, measured by an ion-bombardment extraction method, was found to be as high as 1,000 c.c. per 100 gm. of metal. This measurement was carried out on specimens turned down from the original corroded blocks, and the results would, therefore, indicate that the absorbed hydrogen had penetrated to a considerable depth in the metal.

Such behaviour on the part of aluminium would imply that it can exhibit a condition analogous to that of steel which has been embrittled by pickling in certain circumstances ; this, as is well known, is associated with the absorption of large quantities of hydrogen, which apparently segregates along cleavage planes and lattice imperfections, and has a very deleterious effect on mechanical properties. No phenomenon of this nature has been found in aluminium or its alloys ; but an appreciable uptake of hydrogen by a similar mechanism might have less obvious effects, and play an important part, for example, in corrosion, particularly under stress. The latter possibility has been suggested by Goldowski[2].

Since the experimental results quoted above are at variance with our own experience, we have carried out some tests in which the corrosive conditions were, so far as we can judge, identical with those described by Moreau and Chaudron ; but the hydrogen absorbed by the specimens was determined by a hot-extraction method[3]. In these tests, two specimens of cast 99·99 per cent aluminium, each weighing about 10 gm., were immersed in (N/100) caustic soda for 49 days, the solution being renewed at frequent intervals when the reaction appeared to be slowing down. The specimens each lost about half a gram in weight and were very deeply etched, especially at the grain boundaries. On removal from the solution they were washed in 1 per cent acetic acid and dried without handling. One specimen was degassed without any further treatment, and evolved hydrogen equivalent to 0·47 c.c./100 gm. of metal, and a much smaller volume of other gases, mainly carbon dioxide. The second specimen was skimmed to a depth of about 1 mm. on a lathe before degassing, and in this case the hydrogen content was found to be 0·43 c.c./100 gm., with a lesser volume of other gases than in the first experiment

Other experiments indicate that with the latter treatment the bulk of the gases other than hydrogen, and about 0·05 c.c./100 gm. of the hydrogen itself, is associated with the oxide film which is inevitably present on the metal. The correction to obtain the true value of dissolved hydrogen is probably greater than this for the unturned specimen. We thus find that the hydrogen content of the corroded metal is rather less than 0·4 c.c./100 gm., with no evidence of a high concentration in the surface layers. A gas content of this order is quite normal for cast aluminium, and we therefore conclude that no appreciable absorption of hydrogen takes place under our conditions. We have certainly been unable to detect any effect of the magnitude described by Moreau and Chaudron.

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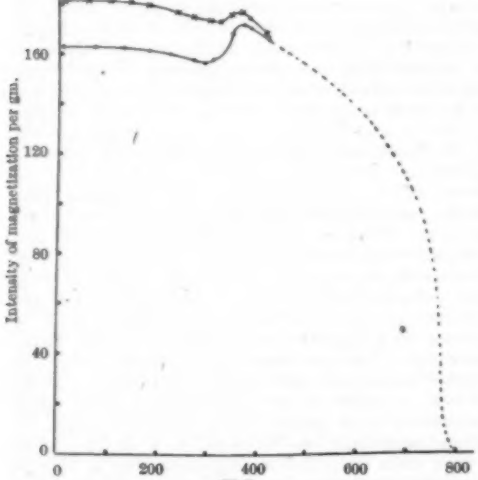
[1] Moreau and Chaudron, *C.R. Acad. Sci. Paris*, **219**, 554 (1944).
[2] Goldowski, A.S.T.M.–A.I.M.E. Symposium on Stress-Corrosion Cracking of Metals, 372 (1944).
[3] Eborall and Ransley, *J. Inst. Metals*, **71**, 525 (1945).

'Spoiling' of Tungsten Steel

It is known that the coercive force of tungsten magnet steel is reduced if the steel is maintained for a period at a temperature of 950–1,000° C. prior to hardening. The steel is then said to be 'spoiled'. In some such samples of tungsten steel the compound WC has been detected, and it has been suggested that the tungsten and carbon remaining in solution are insufficient to promote good hardening[1,2]. Experiments have been made on an unspoiled steel with the following analysis: W, 5·65; C, 0·72; Cr, 0·27; Si, 0·24; Mn, 0·3 per cent.



●—●—, quenched from 850° C.
×——×, annealed at 950° C. for 64 hr. and quenched from 850° C.

Small samples of this steel were heated for various times in an enclosed quartz tube at 950° C. Later, while still in the tube, they were quenched from 850° C. in water. The intensities of magnetization of these samples were measured by means of a Sucksmith balance[3] at various temperatures. The field of 11,300 Oersted was sufficient to produce saturation. The figure shows curves of specific magnetization against temperature for two specimens treated in this way, the periods for which the specimens were kept at 950° C. being zero and 64 hours respectively. The specific magnetization of these specimens at room temperature after annealing in a region between 400° C. and 700° C. is always about 189.

The curves can be explained by assuming that the quenched specimens contain some austenite which is non-magnetic. On heating to 300° C., the austenite is transformed into a magnetic martensite or ferrite. (The change actually occurs slowly between 250° and 300° C., but the curves shown were taken with the temperature rising fairly rapidly, and consequently the transition appears at a slightly higher temperature.) The percentage of austenite can be estimated either (*a*) by assuming that it is proportional to the amount by which the specific magnetization at room temperature is less than that for a completely ferritic specimen, or (*b*) from the increase in the specific magnetization at 300° C. shown in the figure. Results using the two methods of estimation are shown in the table.

	Time at 950° C. (hr.)	σ	% of austenite	
			Method *a*	Method *b*
1	0	161·2	15	12
2	0	162·9	14	12
3	1	170·0	10·5	10
4	4	173·5	7	7
5	64	178·5	5	5

The percentage of retained austenite can be seen to decrease progressively as the time of annealing at 950° C. increases. To explain this result it may be assumed that at 950° C. tungsten and carbon combine to form a separate carbide phase, the reaction proceeding rather slowly and approaching equilibrium exponentially according to the law of mass action. The remaining solid solution becomes less rich in these elements, and since it is the presence of tungsten and carbon that enables austenite to be retained on quenching, the percentage of austenite retained will decrease as the amount of tungsten carbide increases.

The specimens were also examined microscopically, but it was not found possible to estimate the quantity of austenite by this method; but an increase in the patterns usually attributed to WC was observed as the time of annealing at 950° C. increased.

These experiments strengthen the theory that the 'spoiling' of tungsten magnet steel is caused by the formation of a separate carbide phase which reduces the amount of tungsten and carbon available to promote hardening.

We wish to acknowledge our thanks to the Permanent Magnet Association for permission to publish this note.

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M. McCaig

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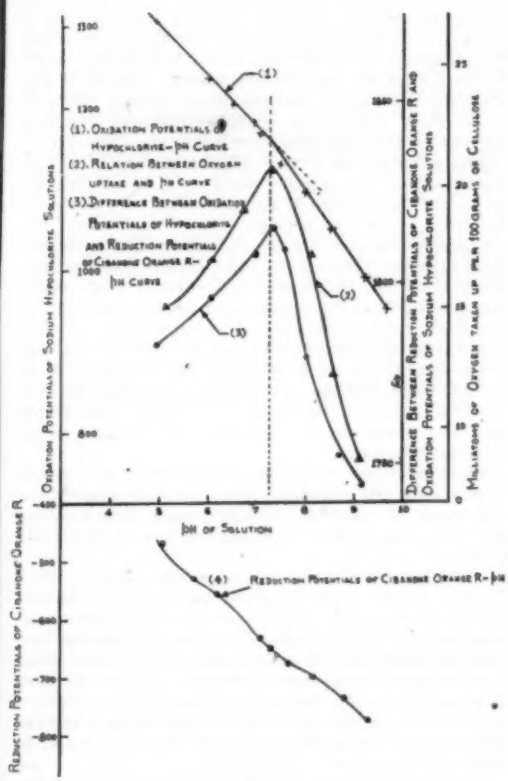
84 Brown Street, Sheffield.

[1] Gregg, J. L., "Alloys of Iron and Tungsten", 221–227 (McGraw-Hill, 1934).
[2] Wainwright, C., *J. Sci. Instr.*, **18**, 97 (1941).
[3] Sucksmith, W., *Proc. Roy. Soc.*, **A, 170**, 551 (1939).

Accelerated Oxidation of Cotton Cellulose in Presence of Reduced Cibanone Orange R

THE rate of oxidation of cellulose by dilute solutions of sodium hypochlorite has been shown to be accelerated if certain vat dyes are also present in the reduced form upon the fibre[1,2]. Ferrous hydroxide precipitated on cellulose exerts a similar influence on the rate of oxidation[3]. The mechanism of this acceleration is not yet clear. It has been suggested[3] that the difference between the oxidation potential of the oxidizing agent and the reduction potential of the vat dye may be the determining factor in the acceleration of the oxidation. The present investigation deals with the measurement of reduction potentials of vat dyes upon the fibre and their influence on the acceleration of the rate of oxidation of the cellulose substrate by dilute sodium hypochlorite solutions.


(1). Oxidation Potentials of Hypochlorite–pH Curve
(2). Relation Between Oxygen uptake and pH Curve
(3). Difference Between Oxidation Potentials of Hypochlorite and Reduction Potentials of Cibanone Orange R–pH Curve
(4) Reduction Potentials of Cibanone Orange R–pH
pH of Solution
Oxidation Potentials of Sodium Hypochlorite Solutions
Reduction Potentials of Cibanone Orange R
Difference Between Reduction Potentials of Cibanone Orange R and Oxidation Potentials of Sodium Hypochlorite Solutions
Millilitres of Oxygen taken up per 100 grams of Cellulose

Loose cotton dyed with Cibanone Orange R was tightly wrapped round a stout platinum wire. The dyestuff on the cotton was chemically reduced, and the free leuco compound was prepared by washing away the soluble impurities with oxygen-free distilled water. The electrode was then immersed in an oxygen-free buffer solution of known hydrogen ion concentration through which hydrogen gas was bubbled vigorously for fifteen minutes. The E.M.F. of the following cell was measured at short intervals:

+ Hg | Hg_2Cl_2,Sat.KCl || Sat.KCl || Leuco Cibanone Orange R dyed cotton in buffer solution | Pt —

The E.M.F. reached a constant value after about fifteen to twenty minutes and remained steady for periods varying between half to one hour. This constant value was taken as the E.M.F. of the cell. The potential of the half-cell

Pt | leuco Cibanone Orange R (dyed cotton in a buffer solution)

was calculated from the E.M.F. of the above cell. This value has been referred to as the reduction potential of Cibanone Orange R. The oxidation potentials of sodium hypochlorite solutions and the oxygen uptake by reduced Cibanone Orange R dyed cotton were measured by the method described by Nabar, Scholefield and Turner[3]. All measurements have been carried out at 30° C. The results are illustrated in the accompanying graphs.

It will be noted that the curve relating *p*H to oxygen uptake closely resembles the curve showing the relation between the *p*H and the difference between the oxidation potentials of hypochlorite solutions and the reduction potentials of Cibanone Orange R. A few other dyes examined show similar behaviour.

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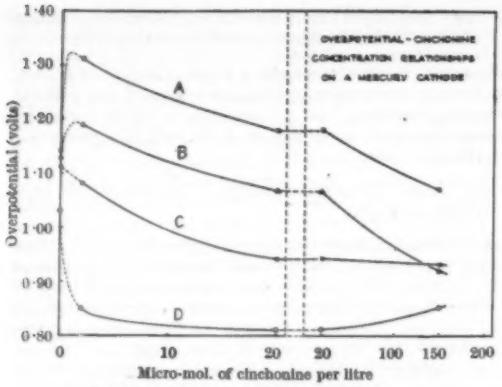
[1] Turner, Nabar and Scholefield, *J. Soc. Dyers and Col.*, **51**, 5 (1935).
[2] Nabar, Scholefield and Turner, *J. Soc. Dyers and Col.*, **53**, 5 (1937).
[3] Nabar and Turner, *J. Soc. Dyers and Col.*, **61**, 258 (1945).

Effect of Alkaloids on Hydrogen Overpotential

IT is well known that certain substances, such as arsenious oxide[1], when added to a solution in which is a working electrode evolving hydrogen, considerably increase the hydrogen overpotential at the cathode. Such substances are often referred to as 'poisons'[2], and a detailed knowledge of their effects on irreversible electrode potentials appears to be of considerable importance in the elucidation of the mechanism of overpotential. It seemed probable that some additives might exist which function as 'activators' and thus decrease hydrogen overpotential at various current densities. Such substances have been found among certain alkaloids of the quinoline group.

Hydrogen overpotential has been measured by the direct method at current densities from 10^{-3} to 10^{-1} amp./sq.cm. on cathodes of mercury, lead, tungsten and platinized platinum in pure aqueous solutions of hydrogen chloride and in solutions containing quinoline, cinchonine, quinine, narcotine and morphine in concentrations from 2 to 150 micro-mol./litre. Marked lowering effects are observed in solutions containing these quantities of the alkaloids named above, particularly at lower current densities on mercury cathodes. Smaller lowering effects occur for lead; tungsten cathodes are little affected, and on platinized platinum all the above-mentioned alkaloids act as poisons.



A, 10^{-1} amp./sq. cm.; *C*, 10^{-2} amp./sq. cm.
B, 5×10^{-2} „ „ ; *D*, 10^{-3} „ „ .

Detailed results for mercury cathodes are given in the accompanying table, and a typical dependence of overpotential on concentration of alkaloid present is shown in the graph for mercury cathodes in solutions containing cinchonine.

EFFECT (APPROXIMATE) OF ALKALOIDS ON OVERPOTENTIAL ON MERCURY

Alkaloid	At 10^{-2}–10^{-3} amp./sq. cm.		Volts	At 10^{-2}–10^{-1} amp./sq. cm.	Volts
Quinoline	Lower conc. :	lowered	0·1	raised	0·1
	Higher conc. :	lowered	0·2	raised	0·2
Cinchonine	Lower conc. :	lowered	0·2	raised	0·1–0·2
	Higher conc. :	lowered	0·2	lowered	0·15–0·2
Quinine	Lower conc. :	lowered	0·2	raised	0·25
	Higher conc. :	lowered	0·1–0·2	raised	0·1–0·2
Narcotine	Lower conc. :	lowered	0·05	raised	0·1–0·2
	Higher conc. :	raised	0·05	raised	0·2–0·3
Morphine	Lower conc. :	lowered	0·05	raised	0·2
	Higher conc. :	raised	0·1	raised	0·3

The most notable features of the present results are that the lowering effects of the alkaloids increase with concentration at a given current density, and that they depend markedly upon the nature of the cathode material. Presence of alkaloid generally decreases the *b* factor of the Tafel equation[3] at low current densities and increases it at high current densities.

The results on mercury may be compared with the observations of Pech[4] and of Herasymenko and Slendyk[5] on the effects of alkaloids on the polarographic half-wave potentials, which were found to be changed by the presence of certain of these substances to more positive values.

The above work forms part of a comprehensive study of the effect of poisons on hydrogen overpotential which is being carried out in this Department. A detailed discussion will be published elsewhere.

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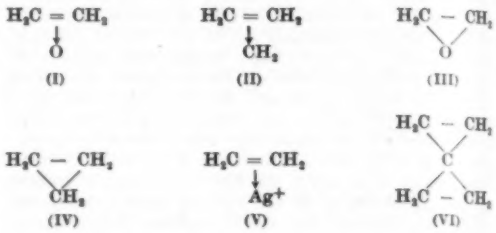
[1] Knorr and Schwarz, *Z. phys. Chem.*, **176**, 161 (1936).
[2] For example, see Hickling and Salt, *Trans. Farad. Soc.*, **37**, 333 (1941).
[3] Tafel, *Z. phys. Chem.*, **50**, 641 (1905).
[4] Pech, *Coll. Czech Chem. Comm.*, **6**, (3), 126 (1934).
[5] Herasymenko and Slendyk, *Coll. Czech Chem. Comm.*, **6**, (4–5), 204 (1934).

Structures of Ethylene Oxide and Cyclopropane

MY suggestion[1] that ethylene oxide and cyclopropane might be portrayed as (I)–(II) rather than (III)–(IV) has been criticized[2,3]. I wish, therefore, to discuss my suggestion further.



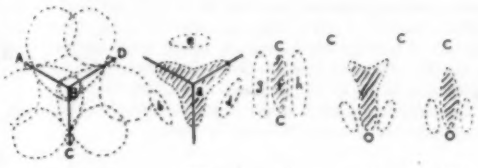
My underlying ideas were: (1) evidence on olefinic donor properties suggests (I)–(II), just as (V) is known; (2) the carbon atoms involved are nearer the trigonal or ethylenic than tetrahedral state. Evidence for (2) seems very strong. (*a*) It is outstanding that epoxy or cyclopropyl groups joined to C=C show just those spectroscopic and chemical properties characterizing conjugation. Theory explains conjugation thus. All the carbon atoms involved are in the trigonal state: 2*p* atomic orbitals on neighbouring carbon atoms overlap to give a non-localized molecular orbital. The conjugation phenomena follow from the delocalization. Hence the idea that ethylene oxide and cyclopropane contain near-trigonal carbon atoms and molecular orbitals which, being built from 2*p* atomic orbitals, inevitably overlap with neighbouring 2*p* atomic orbitals. (*b*) The low dipole moment of cyclopropyl chloride: the high electronegativity of a trigonal carbon atom in its hybrid valencies[5], as in vinyl chloride, explains this. (*c*) The height of the strong CH Raman frequencies and the unsaturation properties of ethylene oxide and cyclopropane.

One is therefore led to structures with carbon atoms near the trigonal state. (I)–(II) suggest the existence of trigonal carbon atoms, non-localized orbitals, unsaturation, conjugating power. (III)–(IV) do not.

(I) suggests resemblance to amine oxides. Such is seen in work by Karrer[4], to which Sir Robert Robinson does not refer: certain epoxy groups *do* lose oxygen readily (→C=C). I do not suppose likeness between (I) and amine oxides to be *very* close: the orbital symmetries involved are so different. Similarly, analogy between (I) and (V) is not *very* close, for O, unlike Ag^+, has further valency orbitals which must be involved: their importance can be seen below.

It is clear that the probable symmetry (from infrared data: *not* from intuition, which would suggest O_3 to be equilateral) of cyclopropane enforces superposition of three forms like (II). The resultant is not (IV), for it is still based on trigonal rather than tetrahedral carbon atoms. In the hybrid, the CH_2 planes must bisect the CCC angles: molecular orbitals are formed by overlap of (*a*) three hybrid sp^2 atomic orbitals, (*b*) 2*p* atomic orbitals. (VII) shows this: *AB*, *CB*, *DB* are CH_2 planes at 90° to the paper. The result has some of the character of (VIII). Two electrons occupy the three-pronged area *a*, two may be found either in *b* or *d* or *e*, and two lie in an orbital

that represents a first overtone of *a*. The latter are 'anti-bonding' electrons: their presence reflects repulsion in (II) between the lone pair and other electrons. *b*, *d*, *e* are regions of high amplitude in an orbital with no actual nodes.



VII VIII IX X XI

The resonance description of cyclopropane on my model is as a hybrid of three forms (II), the molecular orbital description partly as (VIII). The orbital pattern (VIII) to which we have been led is a generalization to three centres of the orbital picture (IX), which theory has evolved to explain two-centre unsaturation and make redundant the old distorted tetrahedral model for ethylene. *f* represents the σ, *g*–*h* the π orbital. (That (IX) and (VIII) *are* the same geometrical pattern applied to two and three centres respectively can be shown by folding filter papers along (i) two diameters at 90°, (ii) three at 60°, making the same cuts in each and opening out; *f* becomes *a*, *g*–*h* become *b*–*d*–*e*.) The molecular orbital picture for ethylene oxide is as (VIII), except that the dipole means *e* is now tenuous, *b*–*d* drawn downwards, the upper prongs contracted. (X) ensues. One reaches the same essential result[5] by considering the single structure (I) as the major resonance form. A $\diagdown$C=O $\diagup$ group has the molecular orbital picture (XI). Some resemblance of ethylene oxide to CH_2CHO may therefore follow. Cationoid character comes from a large partial positive charge on the CC of (X), as on C of $\diagdown$C=O. $\diagup$

(VII) implies, besides (VIII), some localized-bond character. The overlap between any pair of 2*p* atomic orbitals is neither 'sideways' nor 'endwise'. So far as it is the latter, the resulting molecular orbital overlaps little with the third 2*p* atomic orbital, that is, localized bonds at *b*, *d*, *e* result, *a* is vacated and its component atomic orbitals, mixed with the original carbon atomic orbitals, cause some change towards tetrahedral atoms. The angle between the 2*p* axes is such that sideways overlap, with resulting non-localization, is greater than endwise—in accord with the carbon atoms being nearer trigonal than tetrahedral. In cyclobutane the angles are such that localization is greater and four-centre unsaturation less. Even in cyclohexane, however, a greater tendency (than in paraffins) towards 2*p* character in the C—C and of 2*s* in the C—H valencies is shown by CC weakness and CH strength[5].

In azoxy compounds, lone pairs and not bonding electrons are donated. This is not against (I), as ethylene has no lone pair. It is significant that azoxy groups do *not* form strained rings, though far less distortion of natural valency angles is necessary than in (I). A most important stable molecule to consider is spiropentane, usually drawn as (VI). My ideas are readily extended to this molecule, the central carbon atom being digonal and the two CCC planes at 90°.

Dr. McDowell's arguments seem not to affect my model. I do not expect (I)–(II) to show olefinic frequencies: the disturbance is too great for this. I *expect* S⁺—*R* to be able to replace NH or CH_2 or O.

So far as I can see, my model explains qualitatively all the salient facts. I think, therefore, (I)–(II) possible single formulæ, full descriptions (especially with (II)) needing hybridization with like forms; but if entirely new symbols for the binding at issue be suggested, I shall quite agree. I have been mainly concerned to apply wave mechanical principles to the problem—though Sir Robert Robinson apparently does not realize this. As regards co-ordination by bonding electrons, my contribution was to try to combine clear statement with a rational basis for assessing donation probability, namely, ionization potential knowledge.

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[1] Walsh, *Nature*, **159**, 165 (1947).
[2] Robinson, *Nature*, **159**, 400 (1947).
[3] McDowell, *Nature*, **159**, 508 (1947).
[4] Karrer, *Helv. Chim. Acta*, **28**, 474 (1945).
[5] Walsh, in course of publication.

Status of Potato Virus B

Potato virus X is known to exist in many strains. Potato virus B has been considered to differ from all other strains of potato virus X, on account of its reactions on several potato varieties.

Clinch[1] considered 'Up-to-Date streak' to be synonymous with virus B of Bawden[2]. She was not certain whether a strain of X was present in her stock of Up-to-Date, along with the strain causing streak. However, it seems definite that Bawden's material contained a 'normal' X strain, as well as B in some plants at least.

Cockerham[3] described the reactions on several hosts, including a large number of potato varieties, of a virus from Duke of York potatoes. He considered this virus to be pure virus B. Bawden and Sheffield[4], working with this material, showed by cross-absorption tests that B and several strains of X were all serologically related but not identical. One of the X strains used (X^a) resembled B in some host reactions and not in others. They point out that a simple test based on host reactions is not a valid test of relationship.

'Up-to-Date streak' virus in Up-to-Date, supplied by Clinch, has been compared serologically with virus B from Bawden's source in Duke of York.

Rabbit antisera to the virus were prepared from the two sources. *Nicotiana glutinosa*, inoculated directly from potato, was used as the starting material for partially purified preparations of the virus free from tobacco mosaic. These preparations were used in absorption experiments. Cross-absorption tests, made with virus in slight excess, showed that both sources of the virus have an antigenic portion in common (7/8), and that each has a fraction distinct from the other (1/8 in each case), using the serum end-point as an estimate of the fractions.

It is concluded that virus B from Duke of York potato has an antigenic portion differing from the streak virus in Up-to-Date. The reverse is probably true. However, the possibility that part of, or all, this difference is caused by an X-type strain, present along with the streak strain in Clinch's material, has not been eliminated.

It is suggested that virus B is no more a single entity than is virus X. It is possible that many strains of virus X may be found which do not give top necrosis on varieties like Epicure and King Edward. This conclusion, together with the findings of Bawden and Sheffield[4], indicate that there is no sound basis for giving the strains known as 'virus B' any special status within the X group. There seems to be no good reason why the reactions on a few arbitrarily chosen varieties of potato (or any other single host) should have any special significance as a basis for the classification of X strains into groups.

The value of the cross-absorption figures as a quantitative estimate of the 'common' and 'non-common' portions on the particle is very doubtful. Nevertheless, carried out with a number of strains, it may give some indication of the relative extent of antigenic relationship.

My thanks are due to Dr. Phyllis Clinch and Mr. F. C. Bawden for supplies of their material, and to Dr. K. M. Smith and Dr. Roy Markham for helpful criticism.

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April 17.

[1] Clinch, Phyllis E. M., *Sci. Proc. Roy. Dublin Soc.*, **23**, 18 (1942).
[2] Bawden, F. C., *Ann. Appl. Biol.*, **23**, 487 (1936).
[3] Cockerham, G., *Ann. Appl. Biol.*, **30**, 338 (1943).
[4] Bawden, F. C., and Sheffield, F. M. L., *Ann. Appl. Biol.*, **31**, 33 (1944).

A Protozoal Disease of South African Trawled Fish and its Routine Detection by Fluorescence

Recent investigations into the problems of (*a*) 'mealiness' of the cooked flesh of the Cape John Dory (*Zeus capensis*) and (*b*) milky spots in smoked fillets of the stockfish (*Merlucius capensis*) have revealed that the abnormalities are a consequence of heavy infections of the muscle fibre by a protozoal parasite. The parasite is identical to that described by Gilchrist[1] as *Chloromyxum thyrsites* causing the 'pap' condition of the snoek (*Thyrsites atun*). Fantham[2], however, suggested that the organism might be identical to *Chloromyxum quadratum*, Thélohans.

Gilchrist reported that 5 per cent of the snoek catch were so heavily infected as to be of no commercial value, and that microscopic examination of the flesh of twelve fish selected at random and considered perfectly healthy revealed that eight of the fish were infected.

In the John Dory, approximately 25 per cent of the catch landed are extremely emaciated, with the flesh so soft that it cannot be filleted. It is just possible to detect less severe infection at the time the fish is landed by trawlers, by the greater opacity of the infected muscle fibres, while 36–48 hours later the infection is clearly visible as milky areas embedded in the flesh.

In the stockfish there are no visible signs of infection until after the fillets have been smoked, when the infected areas appear as whitish spots embedded in the flesh. The 'milky' spots, on pressing, exude an ooze of disintegrated tissue heavily impregnated with the characteristic spores of the parasite.

The discovery that infected muscle fibres fluoresce under ultra-violet light filtered through Wood's glass has made it possible to survey in large samples of the catch, (*a*) the distribution of infection within the tissues, (*b*) the intensity of infection, and (*c*) the number of fish infected. The infection is limited to single or a few adjacent muscle fibres distributed at random throughout the flesh. Such muscle fibres fluoresce brilliantly in the stockfish, and even deeply embedded infections can be detected without difficulty. In the John Dory, the intensity of the fluorescence is not so great, but is ample to indicate even a single infected fibre in the whole fish. The fluorescence is greatly diminished in salted fish.

The extent of the infection in the trawled fish may be gauged from the following data.

Fish	No. examined	% Infected
John Dory	596	76
Stockfish	660	70

The extent of the infection may vary from a single muscle fibre to a state in the John Dory in which the fluorescing fibres permeate the whole flesh. It is difficult to imagine how such fish can move and live. It is probable that only the numerous spines with which the John Dory is protected save the heavily infected individuals from becoming easy prey to other fish. Heavy infection of the order encountered in the John Dory has not been seen in the stockfish; but there is no clear evidence to indicate whether this is due to greater resistance or to the elimination of the fish as soon as the infection reaches moderate proportions, when muscular movement might be affected.

The John Dory catch is also characterized by the preponderance of female to male in the ratio of approximately 2 : 1. The distribution of the intensities of infection in male and female fish and the proportion of infected individuals among the sexes seems to indicate that the male fish are more susceptible and that the disease progresses more rapidly in the male. There is strong presumptive evidence of considerable mortality in the John Dory from this disease. It is of considerable interest that Gilchrist suggested in 1924 that the occasional meagreness of the annual shoals of snoek visiting the Cape could probably be ascribed to this disease.

Details of this investigation will be published elsewhere.

Rees Davies
E. Beyers
Low Temperature Research Laboratory,
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March 31.

[1] Gilchrist, J. D. F., *Trans. Roy. Soc. S. Africa*, **11**, 263 (1924).
[2] Fantham, H. B., *Proc. S. African Assoc. Adv. Sci.*, 346 (1925).

Population Studies in Fisheries Biology

G. L. Kesteven has stressed[1] the need for a dynamic approach to the study of fish populations. It has been possible recently to develop a mathematical treatment having certain features in common with that of Baronov[2], which bears this necessity in mind, and which we feel will be of value in further consideration of fisheries problems, and in particular has immediate application in the assessment of remedies for overfishing.

Russell's equation[3] expresses the dependence of the yield from a fishery on the vital coefficients of the population (natural mortality, recruitment and growth) and the rate of fishing. In its original form,

this equation is not an analytical tool, as Kesteven points out. It is possible, however, to express these fundamental relationships in a form that would enable application to any population of fish for which there are sufficient data.

We shall define the primary factors that enter into a determination of the rate of yield, in terms of the coefficients of recruitment (B), growth ($W(t)$) and natural and fishing mortalities (M, F), M including a factor for loss by emigration from the area considered. All other factors, such as population density and mesh selection in so far as they influence the rate of yield, do so by virtue of their effect on these primary coefficients, and thus can be incorporated into the equations.

If B is equal to the number of fish attaining fishable size per year, and the coefficients are effective over a period λ years, the fishable life-span of the species, it can be shown that:

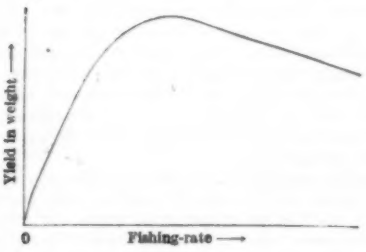
$$Y = \sum_{n=0}^{\lambda-1} \int_{t=n}^{n+1} W(t).F.B.\exp\left(-\int_{\circ} F + M\right) dt,$$

where Y is the yield in weight per annum. It must be emphasized that this, and the following example, apply only to equilibrium condition.

To illustrate the form which the equation may take, we consider the simplest case, where B, M and F are constants, and $W(t) = \alpha + \beta t$.

$$\text{Then } Y = B.F. \int_{\circ}^{\lambda} (\alpha + \beta t) \exp\left(-(F + M)t\right)$$

$$= \frac{B.F}{F+M}\left[\alpha + \frac{\beta}{F+M} - \exp\left(-(F+M)\lambda\right.\right.$$
$$\left.\left.\left(\alpha + \beta\lambda + \frac{\beta}{F+M}\right)\right)\right]$$



There is a field in which this equation can be applied as a first approximation. A fuller treatment requires a determination both of the variable components affecting the primary coefficients and of the significance of possible departures from the steady state.

Further details of this procedure and its applications will appear elsewhere.

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S. J. Holt

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Lowestoft.

[1] *Nature*, **159**, 10 (1947).
[2] Baronov, F., "On the Question of the Biological Basis of Fisheries" (Moscow, 1918).
[3] Russell, E. S., *J. Cons.*, **6** (1), 3 (1931).

Influence of the Medium on the Inactivation of Tetanus Toxin by X-Ray Irradiation

The inactivation of diphtheria toxin by ultra-violet light was first demonstrated by Hertel[1] in 1904. This observation was fully confirmed by other workers for different toxins. Attempts to destroy toxins by means of irradiation with X-rays or radium have hitherto been unsuccessful. Only Ferroux and Muttermilch[2], using exceptionally large doses of radium and highly diluted tetanus toxin, reported destruction of the toxin.

Using considerably greater doses of X-rays than previous authors, we were able to inactivate tetanus toxin and to study the influence of the medium on toxin inactivation *in vitro* by X-rays. The influence of the medium on the destruction by X-rays of viruses, enzymes and other experimental material has already been demonstrated.

Material and Methods. We have used two types of tetanus toxin, prepared in different ways:

(1) A tetanus toxin prepared by culturing tetanus bacilli anaerobically for 14 days in meat infusion broth containing glucose, and afterwards purifying the product by Eaton's method[3]. Such a toxin sample contained 1,000 minimum lethal doses (M.L.D.) in 1 c.c., and yielded 0·14 mgm. nitrogen per 1 ml. in a micro-Kjeldahl test. It will be referred to as $T1$.

(2) The second tetanus toxin sample employed was prepared by culturing tetanus bacilli in Mueller's medium[4] and diluting the product so that it contained 1,000 M.L.D. per 1 ml. This yielded 4·5 mgm. nitrogen per ml. in the micro-Kjeldahl test. It will be referred to as $T2$.

Irradiations were carried out with an Ott tube operated at a tension of 35 kV. and a current of 5 m.amp. with a copper anticathode. The distance between the vessel in which the toxin was irradiated and the focal point was 50 mm., and the intensity of the X-rays was about 90,000 r./min. The window was aluminium foil 30 μ in thickness.

Samples of toxin (0·1 ml.) were irradiated in vials with a diameter of 15 mm., the depth of the liquid in the vials being 0·6 mm. After irradiation the treated toxin solutions were serially diluted to varying extents with saline. At least four white mice, averaging 20 gm. in weight, were inoculated with each of the toxin solutions. Unirradiated control samples of toxin were similarly treated.

The medium was varied by adding a series of proteins and peptones to samples of $T1$.

Results. A dose of 7 million r. suffices totally to destroy the 100 M.L.D. contained in 0·1 ml. of the original standard $T1$ sample, whereas lower dosages only partially inactivated the original 100 M.L.D. The extent of toxin inactivation was determined by the inoculation of varying dilutions of the irradiated original standard toxin sample. In this way it was found that a standard $T1$ sample, after exposure to 4 million r., contained 50 per cent (50 M.L.D.) of the toxin originally present. Doses of 3 million r. inactivated 20 per cent (20 M.L.D.) of the same toxin, and 2 million r. only 5 per cent (5 M.L.D.).

X-ray irradiation of tetanus toxin $T2$ proved to have a less marked effect. Doses of 7 million r. inactivated only 20 per cent of this toxin (20 M.L.D.); 3–5 million r. destroyed approximately 10 per cent (10 M.L.D.). This difference in behaviour between $T1$ and $T2$ is probably associated with the greater purity of tetanus toxin No. 1. W. Dale[5], working

with enzymes irradiated *in vitro*, reported the 'protective' action of certain substances contained in the medium. Similar observations on the protective action of certain substances against X-irradiation have been reported earlier[6-8] for viruses and enzymes.

In order to determine the possible association of different proteins and protein peptones with the enhanced resistance to X-rays, we added a series of these substances to samples of *T*1 before irradiation. The addition of different substances to the medium diminished the X-ray effect on the toxin in varying degrees.

In a number of experiments in which albumin was added, it could be observed that 10 per cent of albumin in the medium completely blocked the inactivating effect of 4 million r. on tetanus toxin (*T*1). Lower albumin content had a less noticeable protective action, and 0·1 per cent of albumin no longer had any demonstrable protective action against irradiation with 4 million r.

Protective action was noted after the addition of albumin, albumin peptone, rabbit serum, protamine, and globulin-peptone. No protective action was induced by the addition of globulin, casein, casein peptone, gelatine, edestin and irradiated toxin.

It is to be noted that substances, such as gelatine, which have a protective effect on certain other test objects such as sperm and hormones, exhibited no protective action on tetanus toxin in our experience.

This investigation has been carried out with the aid of a grant from the British Empire Cancer Campaign.

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A. Back
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Jerusalem. Feb. 3.

[1] Hertel, E., *Z. allgem. Physiol.*, **4**, 1 (1904).
[2] Ferroux, R., and Muttermilch, S., *C.R. Soc. Biol., Paris*, **93**, 608 (1925).
[3] Eaton, M. D., and Cronau, A., *J. Bact.*, **36**, 423 (1938).
[4] Mueller, H. J., and Miller, J., *J. Bact.*, **43**, 763 (1942).
[5] Dale, W. M., *Biochem. J.*, **34**, 1367 (1940).
[6] Lacassagne, A., and Nyka, W., *C.R. Soc. Biol., Paris*, **128**, 1038 (1938).
[7] Friedewald, W. F., and Anderson, R. S., *J. Exp. Med.*, **74**, 463 (1941).
[8] Luria, S. E., and Exner, F. M., *Proc. U.S. Nat. Acad. Sci.*, **27**, 370 (1941).

Value of Adding Cotton-Seed, Okra and Fenugreek to Maize Flour

The association of maize-eating with pellagra and the prevalence of this disease in Egypt have, from time to time, suggested the replacement of maize by some other flour in bread-making; this being impracticable, attempts have been made to raise the nutritive value of maize by supplementing it with other flours. In Egypt, the problem has been unintentionally solved by peasants who have adopted the addition of either fenugreek (*Trigonella Fœnum-græcum* L.), or okra (*Hibiscus esculentus* L.) to maize flour. The resulting bread was very satisfactory, at least so far as added fenugreek is concerned, and it compared well with wheaten bread.

It occurred, however, to those interested in cotton-seed by-products to recover the proteins of the seed after the extraction of the oil and to use the resulting flour as a supplement to maize. The cotton-seed flour is a fine product with yellow-green colour and no particular odour or taste. Its reaction is acid, and it contains 8·75 per cent of moisture, 5·91 per cent of fat, 51·35 per cent of raw proteins, 4·11 per cent of raw fibres, 8·62 per cent of ash and 21·26 per cent of nitrogen-free soluble substances.

Supplementary value of the seed proteins. Unlike wheat, maize flour does not possess the sticky gluten which characterizes wheat. The Egyptian peasant's idea in adding fenugreek to maize flour probably aims at producing a more or less cohesive mass with the help of fenugreek mucilage. When fenugreek is scarce or when it is expensive, the peasants employ instead okra, which contains a similar mucilage. Both fenugreek and okra are local products and are very cheap in comparison with the cotton-seed flour.

It therefore appeared desirable to compare the nutritive value of maize to which cotton-seed flour is added with maize plus fenugreek or okra. Young growing rats were used as experimental animals. Fed as a supplement to a maize diet adequate in all respects except for its protein component, cotton-seed flour at a 4 per cent level enhanced growth in a similar way to that induced by fenugreek or okra supplement at the same level. The increments obtained were 13, 34, 25 and 32 gm. for the basal diet, the basal plus cotton-seed flour, plus fenugreek and plus okra respectively. It might be argued that cotton-seed flour is not bitter, and that unlike fenugreek more of it can be added to maize with impunity. Such addition may increase the nutritive value of the bread and be a point in favour of the cotton-seed flour. It will be remembered, however, that while the bitter taste of fenugreek restricts its use, there are no such restrictions in the case of okra. It was therefore decided to make a fresh comparison with higher supplements of these seeds. Diets of the same compositions but containing 10 per cent of the different supplements were employed, using again young growing rats. When the level was raised to 10 per cent, it was found that the biggest increment was obtained in the case of the okra supplement (77 gm.), then came fenugreek (72 gm.), and finally the cotton-seed flour (48 gm.). If the different supplements were compared by dividing the weight increase by the protein content of the supplement in the different diets (proteins of cotton-seed flour, 51 per cent; fenugreek, 23 per cent; and okra, 18 per cent), then at both the 4 per cent and the 10 per cent levels the protein value of fenugreek is 2·5 times that of cotton-seed flour, while okra is 1·5 times that of fenugreek.

Vitamin content of cotton-seed flour. Biological experiments were made to test for the presence of vitamin B_1 and nicotinic acid, while vitamin A and its precursor carotene were determined spectrophotometrically. Cotton-seed flour contains an amount of vitamin B_1 equivalent to a fifth of that present in an equal weight of a sample of fresh 'Marmite'. The ether-soluble extract of the flour was examined spectrophotometrically and was found to contain no vitamin A, but it contained on the average 6·375 mgm. of carotenoids per cent. As regards nicotinic acid (anti-pellagra and anti-blacktongue factor), feeding experiments with dogs showed that it contained a small amount.

Cotton-seed flour is therefore inferior to fenugreek and okra in its protein value, and the vitamin content is not appreciable.

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March 29.

PARTICLE SIZE ANALYSIS

PARTICULATE material is a general descriptive title for the many forms of matter existing in a state of sub-division into discrete particles. Such materials play an important part in almost all human activities, either as dust particles formed by natural agencies, or as powders produced by the artificial reduction in size of larger fragments of material. Dust is always present in the atmosphere, and though generally regarded as a nuisance, also fulfils useful purposes; but when present in excessive quantities it becomes a menace to health, and much active research is in progress to minimize the harmful effects of dust in mining and industrial atmospheres. Artificially ground powders are of the greatest importance to industry; sometimes their production is the main objective, as in the manufacture of Portland cement or pigments, and fine grinding of immense tonnages is an essential stage in the reduction of metallic ores. The building industry uses large quantities of materials in powdered or granular form, and a knowledge of the size analyses of these is essential. Agriculture and civil engineering are concerned with problems such as soil erosion, silt deposition and the foundations of buildings, for which data on the size characteristics of sedimentary deposits are needed. Thus there can be few manufacturing processes which are not dependent upon the use of powdered materials at some stage, and though the quantities involved may be smaller than in the industries mentioned above, the monetary value may be high, as for example in the fabrication of parts from metal powders.

Empirical methods of examination combined with the results of experience have in the past sufficed to determine the quality and the suitability of a powder for a particular industrial purpose, but for the last twenty years considerable attention has been given to methods of particle-size determination. During this period the literature on the subject has grown rapidly in volume; indeed this abundance is somewhat confusing to those commencing a study of methods of particle-size analysis.

A conference was held on February 4 by the Institution of Chemical Engineers and the Society of Chemical Industry (Road and Building Materials Section) with the object of clarifying this situation and summarizing the results of recent researches. The interest in the subject was even greater than expected, for out of an attendance of about 350 persons, quite a large number were unfortunately unable to gain admission to the meeting hall. The conference was divided into morning and afternoon sessions; at the morning session there were six papers dealing with methods of size analysis, and at the afternoon session five papers dealing with industrial applications of sizing analyses, all presented in abstract*. The authors were selected from research workers in Government or Government-aided research laboratories, universities and industrial research departments particularly concerned in the subject. Although clearly impossible to cover every aspect, the papers presented a cross-section of recent developments in particle-size measurement and typical industrial applications. The chairman of the morning session was Mr. Hugh Griffiths, president of the Institution of Chemical Engineers, and the discussion was opened by Dr. Idris Jones, director general of research for the National Coal Board. Dr. Jones directed attention to the importance of particle-size measurements in the coal industry, and emphasized the need for a study of dust-sampling methods. He especially stressed the need for developing a rapid method of size analysis, otherwise there were long delays in applying research to urgent industrial problems.

Dr. L. H. Lampitt, president of the Society of Chemical Industry, took the chair at the afternoon session, and opened the discussion by directing attention to the many applications of particle-size analysis in the food industry. Some thirty speakers contributed to the discussion during the day; many of the comments referred to technical points of detail which will be very helpful in developing research on the subject; but the problem of simplifying the situation for the newcomer to this field of study was scarcely touched. There appear to be three methods that are most promising for the routine measurement of the fineness or state of sub-division of a powdered material. These are the adsorption method of determining surface area, the permeability to fluid flow as a measure of external surface area, and the light-extinction or turbidimeter method of determining particle-size distribution and surface area. The three methods measure different properties of the powder, however, and several speakers directed attention to the need for a co-operative research which would delineate the characteristics of these methods of examination and enable some correlation of the results to be made. This could be done by a comprehensive series of tests on materials of particular importance to industry, and is clearly a subject for future research. The problem of standardization was not dealt with specifically in the discussion; although the British Standards Institution is now engaged in the preparation of standards for the size analysis of certain materials, an extension to cover powdered materials in general would be of great benefit to industrial research workers.

Prominence was given in several of the papers to the definition of terms, with particular reference to aggregates of particles. Much research on the measurement of particle size has been conducted on the assumption that the particles are individual or discrete entities of crystalline nature; indeed, the dispersal of a sample of powder into such a state is one of the problems of analysis. In many practical applications of powdered materials, however, the individual particles are often clustered together in aggregates known as 'working' or 'operational units' which are not physically constant, for the state of aggregation depends on the treatment to which the powder is subjected; for example, it will be different in the dry and wet states, though other factors exert considerable influence. Future research must be devoted to a study of these aggregates and to methods of measurement which indicate the size of these as well as of the discrete particles composing them.

The determination of particle-size analysis is an essential preliminary to the study of many industrial problems involving particulate materials, and much research has been hindered or even wasted by insufficient or incorrect knowledge of this factor. Thus,

* The authors of papers were as follows:
Methods of Measurement: C. N. Davies (Industrial Health Research Board, Medical Research Council); Dr. S. J. Gregg (University College, Exeter); Dr. H. Heywood (Imperial College of Science and Technology, London); Dr. F. M. Lea and R. W. Nurse (Building Research Station); Dr. D. G. Skinner and Dr. S. Boas-Traube (British Colliery Owners' Research Association); W. H. Walton (Chemical Defence Experimental Station, Porton).
Industrial Applications: Dr. A. C. C. Newman (Paint Research Station); Dr. K. K. Schofield and Dr. E. W. Russell (Rothamsted Experimental Station); Dr. M. L. Smith (Philips Lamps, Ltd.); C. J. Stairmand (Imperial Chemical Industries, Ltd.); H. Whipp and F. W. Bernhardt (Dussek Bitumen and Taroleum, Ltd.).

research on the theory of grinding or on the efficiency of commercial dust filters cannot progress without a knowledge of the size analysis of the materials concerned; and fundamental research on these and many other subjects is impossible until consistent and rapid methods of size analysis have been developed.

This conference was the first of a public nature to be held in Great Britain to consider the properties of powdered materials, and marks an important advance in the study of this branch of applied science. The complete set of papers and the ensuing discussion, both at the meeting and in writing, should become a valuable source of reference on the subject for many years.

HAROLD HEYWOOD

SOCIETY FOR EXPERIMENTAL BIOLOGY

CONFERENCE IN UTRECHT

AT the suggestion of Prof. G. J. van Oordt, the Society for Experimental Biology was invited by the botanists and zoologists of the University of Utrecht to hold a conference there during April 11–14. This was a memorable event in the history of the Society, being the first occasion on which a meeting had been held outside Great Britain. Utrecht and its ancient University have been for long associated with the struggle for the freedom of thought in Europe, and, after the recent relief from a period of intellectual suppression, it was a peculiarly happy environment for scientific discussion.

The response to the invitation was much greater than was expected, and the conference was attended by more than eighty members of the Society and about forty biologists from Holland, as well as a few from Belgium. As usual, there were separate botanical and zoological sessions, one in the Botanical Laboratory which, with the adjacent Botanical Gardens, is directed by Prof. V. J. Koningsberger, the other in the Zoological Laboratory, the two main sections of which, devoted to experimental embryology and to endocrinology, are under the direction of Prof. C. P. Raven and Prof. G. J. van Oordt respectively.

Some fifty-five papers were read which covered a wide field, though many centred around subjects upon which active research is now in progress in Holland—phytohormones, absorption of substances by plants, growth and differentiation of animal tissues, and comparative physiology. During a discussion on the possible influence of phytohormones on the fine molecular structure of the plasma membrane, we learnt that the deficiencies in Holland's war-time diet had prevented the secretion into the urine of auxin-*a*, for which the botanists at Utrecht had therefore been compelled to substitute indolyl acetic acid in their experiments on plant growth. Among other interesting subjects discussed in the Botanical Section were the absorption and transport of ions and the influence on this of illumination, the structure of the cell wall, apogamy in ferns and a quantum interpretation of certain data on phototropism. The Zoological Section devoted a morning to tissue differentiation, beginning with the development of bone and widening out into a general discussion on cellular differentiation. Another set of papers on neurophysiology, mostly of vertebrates, but including one on sea anemones, also provided material for good discussion. The rest of the papers were not so closely interrelated, but it was generally agreed that the meetings were stimulating and led afterwards to much informal discussion of these and other subjects of mutual interest to Dutch and British biologists. All communications were read in English and, to our great admiration, the proceedings were in no way hampered by the fact that our hosts were speaking a language in which they have had little practice in recent years.

During the afternoon of April 12, four of the University's Institutes showed demonstrations illustrating their current research. In the Botanical Institute were demonstrations of microdissection, of micro-chemical methods and of hormone test techniques. In the Physical Laboratory (director, Prof. J. W. M. Milatz) is a biophysical research group working chiefly on problems connected with micro-organisms and photosynthesis, and here we were also privileged to see one of the few surviving original van Leeuwenhoek microscopes in an interesting demonstration of the history of microscopy. Work on experimental embryology and endocrinology was shown in the Zoological Laboratory; and in the Institute of Comparative Physiology, built in 1936 for the late Prof. Jordan with the aid of the Rockefeller Foundation, the research illustrated was mainly concerned with digestion and with the physiology of invertebrate muscle. This was the only occasion on which members of the Society experienced anything approaching disappointment as, owing to the excellence, number and geographical dispersion of the demonstrations, many were unable to see as much as they would have liked, though this was unavoidable.

The general organisation of the Conference and of its subsidiary functions was excellent, and for this we have to thank the local secretary, Mr. J. C. van de Kamer. In the evening of April 11 the delegates were received in the Central Museum by Dr. G. A. W. ter Pelkwijk, Lord Mayor of Utrecht and curator of the University, and by the director of the Museum, Jonkvr. Dr. C. H. de Jonge; and on the following evening there was a reception in the University by the president-curator, Jhr. Dr. L. H. Bosch Ridder van Rosenthal, followed by a chamber music concert by "The Society for Old Music" of works by Purcell and de Fesch. On Sunday, April 13, we were the guests of the Dutch Government in an excursion through North Holland to the Zuider Zee Dyke, and one of the chief engineers, Jr. Volker, and Mr. Botermans from the Governmental Department of Information, kindly acted as guides and explained some of the hydrological and biological problems connected with land reclamation.

By the generous invitation of one of the students' committees of the University of Utrecht, members of the conference were permitted to use as meeting-places and restaurants one of the clubs of the Utrechtsch Studentencorps, and a club of the Utrechtsch Vrouwelyke Studenten Vereeniging. This not only added greatly to the comfort and enjoyment of the proceedings, but also enabled us to understand how the Dutch have successfully solved the problem of a traditional corporate life in a non-residential university. But it must be especially emphasized that nearly all the eighty members of the conference were lodged and entertained in the homes of the University staff and of other professional people in the neighbourhood. In the present very difficult circumstances this is hospitality indeed; and one of the most significant features of the conference was the open-hearted demonstration of personal and informal

friendship which made the occasion one of much more than purely scientific value. This kind of atmosphere is perhaps less easily created at an ordinary international conference, and we hope that this will not be the last occasion on which a scientific society is invited to hold a meeting in another country.

L. C. BEADLE

MOUNT HOPE AND ITS DAIRY CATTLE

THE increase of milk production is one of the desiderata that is commonly accepted as necessary, and one of the equally commonly accepted ways of securing an increase is by the use of a proven sire. This is the more necessary because it has been said by no less an authority than Robert Boutflour that the average production during a lactation is little, if any, more to-day than it has been for a very long time.

It is to this end that the Mount Hope Farm was established, and a complex of investigations into the laws of inheritance among mice, poultry and dairy cattle began. Mr. Parmalee Prentice has now described these investigations (*Agric. History*, Oct. 1946). The work with dairy cattle started in 1916 when the first were bought, but contagious abortion delayed the start of real work on breeding until the herd had been purged of this disease, by which time (1924) a young Guernsey herd had been acquired which was thought likely to be good. For various causes a satisfactory bull did not appear, and in 1925 a bull was bought because he ranked well according to the system of valuing dairy bulls developed at the Maine Agricultural Experiment Station. This system is based on a comparison of a bull's mates and of his daughters; if the daughters' milk yield was higher the bull was advantageous, if lower the bull was detrimental. The amount of the increase was considered to be a measure of the bull's influence on milk yield.

Misfortune followed the choice, for the bull became impotent and a new bull was selected on the Turner measure for proven sires; but this was found unsatisfactory, and this particular system is no longer used "because it has been found that it over-estimated the inheritance which the sire contributed to its offspring"; and Mr. Parmalee Prentice and his co-workers found it conceivable that the daughters of this bull were good "not only because his influence was good but also because their dams had contributed as much as the sire"—which seems not unreasonable.

They then proceeded to work out a system of their own which they named the Mount Hope 'index', "a correct method of determining a bull's breeding worth from his daughters' records after allowance is made for the dam's influence upon the daughters' productivity". The index was first announced in 1927 and has now been before the world for twenty years.

"Bull indexes are computed by comparing the production records of the daughters and mates of the bull. In order to compare the production of the daughters with the production of their dams and to make comparisons between other cows of different ages, our statistics of milk production since 1936 . . . are always in terms of the mature equivalent. The index is then always applied to a comparatively small number of dam-daughter pairs. Moreover seasons vary; food and management are different in different barns and frequently change in the same barn. The physical condition of the cattle varies, and the result of it all is that though we are able with assurance to tell a good cow from a poor one and in general to tell how good a particular cow is, we are never able in measuring production records to tell with scientific precision the productive ability of a particular cow."

In many places the Mount Hope index has been accepted and is being used. In others, and perhaps the majority, the index is regarded with some scepticism. The need for proven sires and the sons of proven sires in dairy cattle breeding is fairly generally accepted, and records have been adopted so that performance may rank alongside 'pedigree'—one of the qualifications of which the Mount Hope workers are most critical. There has been a good deal of controversy about the Mount Hope dairy cattle and the Mount Hope index, and the essay by Mr. Parmalee Prentice in *Agricultural History* of October 1946 tells the whole story of the work that has been done there. The quarterly is the organ of the American Agricultural History Society, the offices of which are at Room 3870, South Agricultural Building, Washington 25, D.C.; and the annual subscription is four dollars.

G. E. FUSSELL

RELEASE OF INFORMATION ON ATOMIC ENERGY*

THE National Research Council of Canada is making available a number of reports, recently taken off the secret list, on subjects in the fields of theoretical physics and applied mathematics. These reports, which are either too long for journals or are summaries of other work, will be reproduced by the multilith process and will be available at a small charge from the Plans and Publications Section of the National Research Council, Ottawa.

Much material in the hands of the Council is being published in Canadian scientific journals, but the titles mentioned below represent a few which for special reasons cannot be dealt with in that way.

LIST OF DECLASSIFIED REPORTS

MT-1	The Functions $E_n(x) = \int_1^\infty e^{-xu} u^{-n} du$	G. Placzek
MT-12	Elementary Approximation in the Theory of Neutron Diffusion	P. R. Wallace and J. LeCaine
MT-4	Notes on Diffusion of Neutrons without Change in Energy	G. Placzek and G. Volkoff
MT-131	A Table of Integrals involving $E_n(x) = \int_1^\infty e^{-xu} u^{-n} du$	J. LeCaine
MT-88	Influence of a Small Black Sphere upon the Neutron Density in an Infinite Non-Capturing Medium	B. Davison
MT-232	Influence of an Air Gap surrounding a Small Black Sphere upon the Linear Extrapolation Length of the Neutron Density in the Surrounding Medium	B. Davison
MT-93	Influence of a Large Black Sphere upon the Neutron Density in an Infinite Non-Capturing Medium	B. Davison
MT-112	Angular Distribution due to an Isotropic Point Source and Spherically Symmetrical Eigen-Solutions of the Transport Equation	B. Davison
MT-135	Influence of a Large Black Cylinder upon the Neutron Density in an Infinite Non-Capturing Medium	B. Davison
MT-124	Large Spherical Hole in a Slightly Capturing Medium	B. Davison
MT-136	Neutron Density at the Centre of a Small Spherical Cavity	B. Davison

* British declassified reports are announced in *Nature*, March 22, p. 411.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Tuesday, May 27

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Maurice Caullery: "Marine Biology on the French Coast in the Last Hundred Years".*

Wednesday, May 28

INSTITUTE OF FUEL (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Dr. E. A. Watson and Dr. J. S. Clarke: "Combustion and Combustion Equipment for Gas Turbines".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 5 p.m.—Sir Harold Spencer Jones, F.R.S.: "Modern Astronomical Instruments" (Trueman Wood Lecture).

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Waldorf Hotel, Aldwych, London, W.C.2), at 5.30 p.m.—Annual General Meeting.

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON STUDENTS' SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 7 p.m.—Annual General Meeting.

Thursday, May 29

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. M. S. Bartlett: "Multivariate Analysis".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. J. K. Northrop: The Thirty-fifth Wilbur Wright Memorial Lecture.

TELEVISION SOCIETY (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Dr. D. Starkie: "Plastic Lenses in Television Projection".

Friday, May 30

PHYSICAL SOCIETY (in the Physics Department of Imperial College, Imperial Institute Road, London, S.W.7), at 5 p.m.—Scientific Papers.

Saturday, May 31

BRITISH PSYCHOLOGICAL SOCIETY (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 10.30 a.m.—"The Film in Education".

Tuesday, May 27—Saturday, May 31

TEXTILE INSTITUTE (at Portrush, Co. Antrim).—Annual Conference. "Developments in the Production and Processing of Textiles."

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN PHYSICAL CHEMISTRY, a LECTURER IN PHARMACEUTICAL CHEMISTRY, a LECTURER IN METALLURGY, a LECTURER IN PHYSICS, and a LECTURER IN BIOLOGY—The Registrar, College of Technology, The Newarke, Leicester (May 31).

SENIOR ASSISTANT IN THE MECHANICAL ENGINEERING DEPARTMENT, and a LECTURER IN MATHEMATICS AND PHYSICS, at the Rutherford College of Technology—The Director of Education, City Education Office, Northumberland Road, Newcastle-upon-Tyne 1 (May 31).

LECTURER IN CHEMISTRY AND METALLURGY—The Registrar, Technical College, Sunderland (May 31).

CHAIR OF PHYSIOLOGICAL CHEMISTRY—The Secretary of the University Court, The University, Glasgow (May 31).

SENIOR LECTURER IN MATHEMATICS—The Principal, Chelsea Polytechnic, Manresa Road, London, S.W.3 (May 31).

HEAD OF THE DEPARTMENT OF CHEMISTRY AND DYEING, Bradford Technical College—The Director of Education, Town Hall, Bradford (May 31).

SCIENCE LECTURER to teach at least two of the following subjects: Biology, Chemistry, Physics, Mathematics, a Modern Language—The Principal, Aston Technical College, Whitehead Road, Birmingham 6 (May 31).

READERSHIP IN MEDICAL PARASITOLOGY at the London School of Hygiene and Tropical Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 2).

GRADUATE TEACHERS (2) to take courses up to Higher Certificate standard in (*a*) the MECHANICAL ENGINEERING DEPARTMENT to teach subjects of Heat Engines, Strength of Materials, Theory of Machines, and Drawing and Design; and (*b*) the ELECTRICAL ENGINEERING DEPARTMENT to take all subjects, including Mathematics—The Secretary, School of Engineering and Navigation, High Street, Poplar, London, E.14 (June 5).

LECTURER (Grade III) IN GEOGRAPHY—The Registrar, Queen Mary College, Mile End Road, London, E.1 (June 7).

LECTURER to teach PHYSICAL CHEMISTRY—The Registrar, University College, Hull (June 7).

PHYSICIST to assist in research on application of physics in medicine, and a JUNIOR PHYSICIST to take part in clinical, teaching and research work—The Secretary, Royal Cancer Hospital (Free), Fulham Road, London, S.W.3 (June 9).

LECTURER (Grade I) IN MECHANICAL ENGINEERING, and a LECTURER (Grade I) IN ELECTRICAL ENGINEERING—The Principal, Heriot-Watt College, Edinburgh (June 9).

INSPECTOR OF EXPLOSIVES—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 1878 (June 14).

LECTURER, and DEMONSTRATORS (2), IN THE DEPARTMENT OF CHEMICAL PATHOLOGY, and an ASSISTANT LECTURER IN PHARMACOLOGY—The Dean, Guy's Hospital Medical School, London, S.E.1 (June 14).

ASSISTANT LECTURER IN CHEMISTRY, and a LECTURER (Grade II) IN BOTANY—The Registrar, University College, Southampton (June 14).

SCIENTIFIC ASSISTANT—The Director, School of Agriculture, Cambridge (June 14).

ASSISTANT (full-time), and an ASSISTANT (part-time), IN THE DEPARTMENT OF PSYCHOLOGY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (June 14).

ASSISTANT LECTURER (man or woman) IN AGRICULTURAL CHEMISTRY—The Registrar, Wye College, Wye, Ashford, Kent (June 14).

LECTURERS IN AGRICULTURE, AGRICULTURAL CHEMISTRY, AGRICULTURAL ZOOLOGY, MECHANICAL ENGINEERING, CIVIL ENGINEERING, BOTANY, CHEMISTRY, PATHOLOGY AND BACTERIOLOGY, ANATOMY, PHYSIOLOGY AND HISTOLOGY, SURGERY AND MEDICINE, for Gordon Memorial College, Khartoum, Sudan—The Secretary, Inter-University Council, 8 Park Street, London, W.1 (June 15).

CHAIR OF PHYSIOLOGY, a LECTURER IN SPECIAL SENSE PHYSIOLOGY, and a LECTURER IN HISTOLOGY—The Registrar, University College of South Wales, Cathays Park, Cardiff (June 15).

ASSISTANT LECTURER (Grade III) IN MATHEMATICAL PHYSICS—The Secretary, The University, Edmund Street, Birmingham 3 (June 15).

LECTURER IN ROMANO-BRITISH ARCHÆOLOGY—The Registrar, The University, Leeds 2 (June 15).

SENIOR PHYSICAL METALLURGISTS (2), and METALLURGICAL TECHNICIANS (2), by the Department of Scientific and Industrial Research, New Zealand—The High Commissioner for New Zealand, 415 Strand, London, W.C.2 (June 15).

LECTURER IN CHEMISTRY—The Registrar, Trinity College, Dublin (June 15).

LECTURERS (2) IN MATHEMATICS in the Natal University College—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (June 16).

CHAIR OF CHILD HEALTH—The Secretary, The University, Aberdeen (June 16).

ASSISTANT LECTURERS (2) IN BOTANY (preferably with experience in Cell Physiology or Anatomy)—The Registrar, The University, Manchester (June 16).

LECTURER (Grade II) IN THE DEPARTMENT OF INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, The University, Liverpool (June 20).

LECTURER (Grade II) IN GENETICS—The Registrar, University College, Southampton (June 21).

LECTURER IN MATHEMATICS, or an ASSISTANT to the Professor—The Registrar, Trinity College, Dublin (June 21).

LECTURER IN MECHANICAL ENGINEERING—The Registrar, Queen Mary College, Mile End Road, London, E.1 (June 23).

CHAIR OF GEOGRAPHY at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 25).

READERSHIP IN ORGANIC CHEMISTRY at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 26).

ASSISTANT LECTURER (Grade III) IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, University College, Gower Street, London, W.C.1 (June 30).

ASSISTANT LECTURER (Grade III) IN GEOLOGY—The Secretary, The University, Edmund Street, Birmingham 3 (June 30).

I.C.I. RESEARCH FELLOWSHIPS IN PHYSICS and CHEMISTRY, including Physical and Organic Chemistry, Biochemistry, Chemotherapy and Pharmacology—The Secretary, The University, Edinburgh (June 30).

ASSISTANT IN THE CIVIL AND MECHANICAL ENGINEERING DEPARTMENT—The Secretary of the University Court, The University, Glasgow, W.2 (June 30).

CHAIR OF ARCHITECTURE—The Acting Registrar, The University, Sydney, Australia (July 31).

SENIOR TECHNICIAN FOR PHYSICS DEPARTMENT—The Secretary, Mount Vernon Hospital and the Radium Institute, Northwood, Middx.

LECTURER IN THE DEPARTMENT OF MATHEMATICS, and LECTURER IN THE DEPARTMENT OF APPLIED CHEMISTRY—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

TECHNICAL RESEARCH ASSISTANT by the Professor of Physiology—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

ASSISTANT LECTURER IN PHYSICS—The Secretary, Royal Technical College, Glasgow.

SCIENTIFIC OFFICER (Electrical Engineering and Instrumentation, temporary) at the Atomic Energy Research Establishment, Harwell, Didcot, Berks.—The Secretary, Ministry of Supply, Est.8C, Room 193, Shell Mex House, Strand, London, W.C.2.

LABORATORY ASSISTANT IN THE DEPARTMENT OF ZOOLOGY—The Secretary to the Governors, Royal Holloway College, Englefield Green, Surrey.

CHIEF INSTRUMENT MAKER FOR NATURAL PHILOSOPHY DEPARTMENT—The Professor of Natural Philosophy, Royal Technical College, Glasgow.

EXPERIMENTAL OFFICER for testing dairy plant and equipment—The Secretary, National Institute for Research in Dairying, Shinfield, Reading.

LECTURER IN THE ENGINEERING DEPARTMENT, and a LECTURER to teach PHYSICS to the standard of Intermediate B.Sc. and some MATHEMATICS—The Principal, County Technical College, Guildford, Surrey.

ASSISTANT to teach CHEMISTRY in the Technical Day School, and up to Intermediate B.Sc. degree standard in the Technical College—The Principal, Technical College, West Hartlepool.

SCIENTIFIC ASSISTANTS (male or female) by the Ministry of Supply for chemical work, mainly of an analytical nature, at the Ministry of Supply Factory, Springfield, near Preston, in connexion with the Atomic Energy Production programme—The Appointments Officer, Ministry of Labour and National Service, 1–6 Tavistock Square, London, W.C.1, quoting K.S.337.